



FDM 11-26-1 General

February 25, 2011

1.1 General

The modern roundabout is a subset of many types of circular intersections. The term modern roundabout and roundabout are used interchangeably throughout this document. The roundabout is a one-way circular intersection with specific design control features. The term "modern roundabout" is used in the United States to differentiate roundabouts from the older and often large diameter non-conforming traffic circles, rotaries or very small traffic calming circles used on residential streets.

Traffic circles fell out of favor in this country by the mid 1950's because they encountered safety and operational problems as traffic volumes increased beyond their operational thresholds. However, substantial progress has been achieved in the subsequent design of circular intersections, and the modern roundabout should not be confused with the traffic circles of the past.

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals, and will process a wide range of side road volumes. Roundabouts can improve safety by simplifying traffic movements, reducing vehicle speeds, and providing a clearer indication of the driver's right of way compared to other forms of intersection control. The required intersection sight distance is approximately half what is required for a signalized intersection because of reduced intersection speeds.

The following is a list of locations where a roundabout has high potential.

1. Intersections with a high-crash rate or a higher severity of crashes.
2. Where an existing intersection is failing, for any reason.
3. Where other alternatives are expensive.
4. Where aesthetics are an objective.
5. Transitions in functional class or desired speed change (including rural to urban transitions).
6. Where a random/continuous arrival pattern exists.
7. Where a random/continuous traffic pattern is desired or platoons are especially expensive and inefficient (on-ramps, bridges)
8. Freeway ramp terminals
9. High-speed rural intersections.
10. Intersections of dissimilar functional class (arterial-arterial, arterial-collector, arterial-local, collector-collector, collector-access).
11. 4-leg intersections with entering volumes are less than 8,000 vph or approximately 80,000 ADT
12. 3-leg intersections of any volume
13. 2-way stop control intersections with a high-crash rate or a higher severity of crashes
14. Intersection of two signalized progressive corridors where turn proportions are heavy (random arrival is better than off-cycle arrival).
15. Closely spaced intersections where signal progression cannot be achieved.
16. Locations where future access will be added to the intersection.
17. Replacement of 4-way stops
18. Intersections near schools
19. Other intersections where safety is a major concern, such as HSIP Funds.

FHWA and AASHTO have made intersection safety a high priority. The objective is to improve the design and operation of highway intersections. When compared to signalized intersections, studies by the Insurance

Institute for Highway Safety [1] show that roundabouts typically reduce overall delay and congestion, increase capacity, and improve safety. For example, right-angle collisions are a prominent cause of death at signalized intersections. Studies by the Insurance Institute for Highway Safety show that signalized intersections converted to roundabouts experienced 75 percent fewer injury crashes, 90 percent fewer fatality crashes, and fewer crashes overall.

Critical to the acceptance of the roundabout intersection concept is overcoming the internal and external skepticism of its advantages and value compared to stop controlled or signalized intersections. Meet with local officials and adjoining property owners early in the process to address potential political or economic impacts. Designers should also coordinate presentation materials with region staff as well as the Bureau of Project Development in an effort to present a consistent unified approach for roundabout implementation throughout the state.

1.2 Modern Roundabout vs. Other Circular Intersections

The modern roundabout is defined by three basic principles that distinguish it from a traffic circle.

1. Yield-at-Entry - Vehicles approaching the circular intersection must wait for a gap in the circulating flow, or yield, before entering the circle.
2. Traffic Deflection - Traffic entering the roundabout is directed or channeled to the right with an appropriate curved path into the circulating roadway that avoids the central island.
3. Geometric Curvature - The radius of the circular road and the angles of entry can be designed to slow the speed of vehicles. Key geometric design parameters and the fastest speed path are critical to achieve proper design.

On the surface, modern roundabouts, old traffic circles and rotaries look similar; however, there are subtle differences that distinguish the two intersection concepts. The fundamental difference is their differing design philosophies. Modern roundabouts control and maintain low speeds for entering and circulating traffic. This is achieved by small diameters and low-speed entry geometry. By contrast, traffic circle geometry encourages high-speed merging and weaving, made possible by larger diameters and large high-speed entry radii. Modern roundabouts control vehicle speed by geometric design elements that allow only slow speeds therefore creating safer driving conditions. The common characteristics distinguishing a modern roundabout from a traffic circle or a rotary type intersection are summarized in [Table 1.1](#).

Table 1.1 Distinguishing Characteristics of Modern Roundabouts

Feature	Modern Roundabout	Traffic Circle or Rotary
Control at Entry	Yield at entry	Stop, signal, or give priority to entering vehicle.
Operational Characteristics	Vehicles are sorted by destination at the approach. Weaving within the circulatory roadway is minimized.	Weaving is unavoidable and weaving sections are provided to accommodate conflicting movements.
Deflection	Large entry angle helps to create entry deflection to control speed through the roundabout.	Entry angle likely to be reduced to allow higher speed at entry.
Speed	Maintain relatively low speeds (< 25 mph)	Higher speeds allowed (> 25 mph)
Circle Diameter	Smaller diameters improve safety.	Larger diameters allowed. Small diameter circle sometimes used for traffic calming.
Pedestrian Crossing	No pedestrian activity on central island.	Some large traffic circles allow pedestrian crossing to and from the central island.
Splitter Island	Required	Optional
Parking	No parking on the circulatory roadway or in close proximity of the yield line.	On large traffic circles, occasional parking permitted within circulating roadway.

1.3 Advantages and Disadvantages

[Table 1.2](#) lists the advantages and disadvantages of roundabouts versus other intersection alternatives.

Table 1.2 Advantages and Disadvantages of Roundabouts vs. Other Alternatives

Category	Advantages	Disadvantages
Safety	<p>Reduced number of conflict points compared to other non-circular intersections.</p> <p>Elimination of high angles of conflict and lower operational speeds; fewer and less severe accidents.</p> <p>Reduction in conflicting speeds passing through the intersection.</p> <p>Reduced decision making at point of entry.</p> <p>Long splitter islands and other geometric features provide good advanced warning of the intersection.</p> <p>Raised level of consciousness for drivers.</p>	<p>Crashes may temporarily increase due to improper driver education.</p> <p>During emergencies, signalized intersections can preempt control.</p>
Capacity	<p>Traffic yields, nonstop, continuous traffic flow.</p> <p>Generally higher capacities experienced.</p>	<p>Coordinated signal systems can increase capacity of the network.</p>
Delay	<p>Generally reduced delay as compared with an equivalent volume for signalized intersection.</p> <p>During off-peak hours, signal timing can create undue delay at signalized intersections.</p>	<p>As queues develop, drivers accept smaller gaps, which may increase crashes.</p>
Cost	<p>Maintenance of signals (heads, loop detectors, controllers).</p> <p>Lower accident rate and severity; reduced accident costs.</p>	<p>Central island landscaping maintenance.</p> <p>Illumination cost.</p>
Pedestrians & Bicyclists	<p>Splitter islands provide pedestrian refuge and shorter one-directional traffic crossing.</p> <p>Low speed conditions improve bicycle and pedestrian safety.</p>	<p>Pedestrians, especially handicapped may experience increased delay in securing acceptable gaps to cross.</p> <p>Longer travel path.</p>
Environmental	<p>Reduced starts and stops; reduced air pollution.</p>	
OSOW Freight Network	<p>Reduction of potential obstacles at intersections (traffic signals, signing, median islands).</p>	<p>The geometric design may be challenging to allow the navigation of OSOW vehicles.</p> <p>Additional right-of-way may be needed to accommodate OSOW vehicles.</p>

A roundabout can provide a possible solution for locations that experience high crash rates or crash trends by reducing the number of conflict points where the paths of opposing vehicles intersect. For example, over half of the crashes at conventional intersections occur when a driver either; misjudges the distance or speed of approaching vehicles while making a left turn, or violates a red light or stop sign resulting in a right angle collision. Such crashes would be eliminated with a roundabout, where left turns and crossing movements are prohibited. Furthermore, collisions at roundabouts involve low speeds and low angles of impact, and therefore, are less likely to result in serious injury for all road users. Crash evaluation is an important process to complete for any intersection improvement alternative. Crash evaluation will consist of reviewing individual crash records and will typically include factors such as location, date, type of crash, time of day, age of driver, weather conditions, severity of crash, and other important information to assess the problem(s), patterns and potential improvement need. Pedestrians are more safely accommodated since the vehicular speeds are slower and crossing tasks are simplified by the presence of the refuge area in the splitter islands.

When considering methods to increase the capacity of an intersection, a roundabout can be an alternative to stop or signal controlled intersections. With conventional signal controls, only alternating streams of vehicles are permitted to proceed through an intersection at one time, which means a loss of capacity when the intersection clears between phases. In contrast, the only restriction on entering a roundabout is the availability of a gap in the circulating flow. The reduced speeds within the roundabout will allow the approaching driver to safely select a gap that is relatively small. By allowing vehicles to enter simultaneously from multiple approaches using short headways, a possible advantage in capacity can be achieved with a roundabout. This advantage becomes more prominent when the volumes of left or right turning movements are relatively high.

By constructing a pair of roundabouts at the ramp intersections, capacity improvements to the interchange can be accomplished without the costly requirements of widening the structure to carry additional lanes over or under a freeway, or expressway (see [FDM 11-30-1](#) for more information on interchanges).

Roundabouts can produce operational improvements in locations where the space available for queuing is limited. Roadways are often widened to create storage for vehicles waiting at red lights, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes between intersections. One possible application can be found at diamond interchanges, where high left turn volumes can cause signals to fail.

Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be a good fit for such intersections, because they do not require signal phasing. The ability of a roundabout to accommodate high turning volumes, make them especially effective at “Y” or “T” junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout. Intersection sight distance for roundabouts is about half what it is for other intersection treatments because of reduced intersection speeds.

Another possible application is where access is controlled with raised medians. Roundabouts would facilitate left turns and U-turns to access properties on the opposite side of the highway.

1.4 Roundabout Categories

Roundabouts are categorized by size and environment. The following is a list of basic categories explained in FHWA, Roundabouts: An Informational Guide [2]. (FHWA Roundabout Guide) There will be situations where categories are not applicable. The planning process and final design methodologies for roundabouts are to be based on “principles” versus strict rules or one-size fits all standards. For example there are no categories for transitional areas and the final design will depend on various factors.

1.4.1 Mini-roundabouts

Mini-roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

1.4.2 Urban Compact Roundabout

Urban compact roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

1.4.3 Urban Single-Lane Roundabout

This type of roundabout is characterized as having a single-lane entry at all legs and one circulatory lane. The roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a non-traversable central island, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. The smaller inscribed diameter roundabouts shown in [FDM 11-26 Table 20.3](#) may accommodate the WB-65. The minimum inscribed diameter to accommodate a WB-65 is 120 feet. Where long trucks are anticipated, verify that the circulating roadway width and the truck apron can accommodate off-tracking of a WB-65 design vehicle. If the roundabout is located on the OSOW Freight Network, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle.

1.4.4 Urban Multilane Roundabout

Urban multilane roundabouts are roundabouts in urban areas that have at least one approach leg with two or more entry lanes. They include roundabouts with entries on one or more approaches that flare from one to more lanes or the approach is a multilane facility. These require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The speeds at the entry, on the circulatory roadway, and at the exit are similar to those for the urban single-lane roundabouts. Again, it is important that the vehicular speeds be consistent throughout the roundabout. The geometric design includes raised splitter islands, a non-traversable central island, and appropriate horizontal deflection, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. A truck apron should be included to allow the semi tractor to stay in the inner lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65. If the roundabout is located on the OSOW Freight Network, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle.

1.4.5 Rural Single-Lane Roundabout

Rural single-lane roundabouts generally have high speeds on the approach roadway in the range of 45 to 55 mph. They require supplementary geometric and traffic control device treatments on the approach roadway to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulatory roadway, and at the exits. This is permissible if few pedestrians are expected at these intersections, currently

and in the future. A truck apron should be included to allow the semi tractor to stay in the lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65. If the roundabout is located on the OSOW Freight Network, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle.

Other geometric design elements include raised and extended splitter islands, a non-traversable central island, and adequate horizontal deflection.

Rural roundabouts that may one day become part of an urbanized area should be designed as urban roundabouts, with slower speeds and pedestrian treatments. In the interim, design them with supplementary approach and entry features to achieve safe speed reduction.

1.4.6 Rural Multilane Roundabout

Rural multilane roundabouts have speed characteristics similar to rural single-lane roundabouts with approach speeds in the range of 45 to 55 mph. They differ in having two or more entry lanes, or entries flared from one or more lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural multi-lane roundabouts mirror those of their urban counterparts. The main design differences are designs with higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that may one day become part of an urbanized area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. In the interim, design them with approach and entry features to achieve safe speed reduction. A truck apron should be included to allow the semi tractor to stay in the inner lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65. If the roundabout is located on the OSOW Freight Network, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle.

1.5 Defining Physical Features

The defining features of a roundabout are shown in [Figure 1.1](#) and described in [Table 1.3](#).

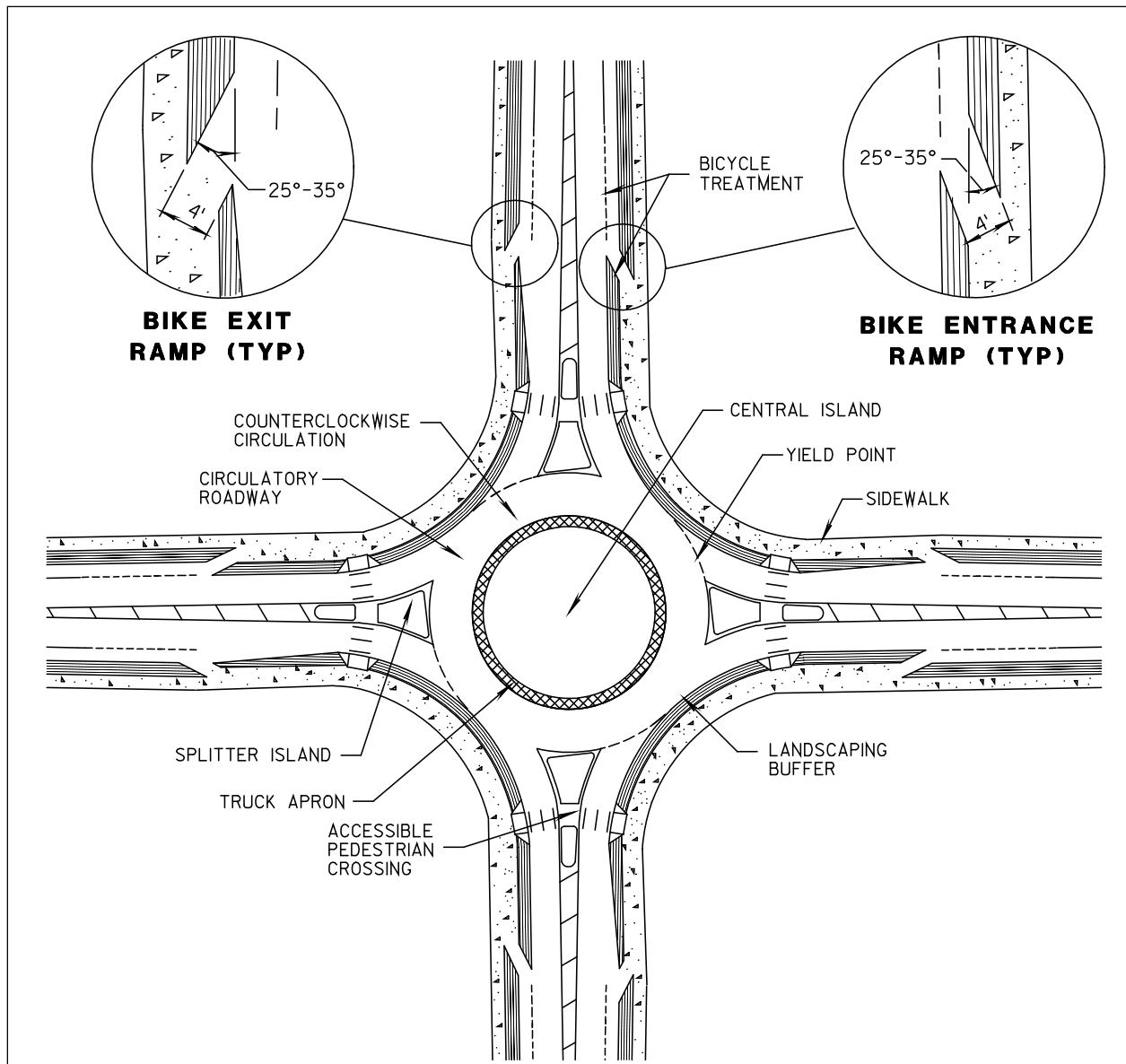


Figure 1.1 Roundabout Features

Table 1.3 Roundabout Features

Feature	Description
Central island	The raised area in the center of a roundabout around which traffic circulates.
Splitter island	A raised curb island (special situations may be painted) area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and to provide refuge for pedestrians crossing the road in two stages.
Circulatory roadway (counter clockwise circulation)	The curved path used by vehicles to travel in a counterclockwise fashion around the central island. The width of the circulatory roadway is typically 1.0 to 1.2 times the width of the widest entry width.
Truck Apron	The traversable portion of the central island adjacent to the circulatory roadway. It is required to accommodate snow plows and the wheel off-tracking of trucks, and OSOW vehicles.
Yield Point	A point of demarcation separating traffic approaching the roundabout from the traffic already in the circulating roadway. The yield point is usually defined by dotted edge line pavement marking. Entering vehicles must yield to circulating traffic.
Accessible pedestrian crossings	Provide accessible pedestrian crossings at all roundabouts. The crossing location is set back from the yield line, typically one car length. The splitter island is cut to allow pedestrians, wheelchairs, strollers, and bicycles to pass through.
Bicycle treatments	Bicycle treatments at roundabouts provide bicyclists the option of traveling through the roundabout either by riding in the travel lane as a vehicle, or by exiting the roadway and using the crosswalk as a pedestrian, or as a cyclist using the shared-use path, depending on the bicyclist's level of comfort. Bicycle exit ramps should generally leave the roadway within a 25 to 35 degree angle range. Bicycle entrance ramps should generally enter the roadway within a 25 to 35 degree angle range. The entrance and exit ramps should be located approximately 50-150 feet from the circulating traffic to allow the bicyclist an opportunity to transition onto a path away from the circulatory roadway.
Landscaping buffer	Landscaping buffers are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection as long as they are placed outside the required sight limits.
Sidewalk	Pathway for pedestrians to walk. In the urban environment it is common to provide a multi-use path at the perimeter of the roundabout to accommodate pedestrians and bicyclists.

1.6 References

- [1] Insurance Institute for Highway Safety publications, May 13, 2000; July 28, 2001; November 19, 2005; www.iihs.org
- [2] "Roundabouts: An Informational Guide," Publication No. FHWA-RD-00-067, June 2000 <http://www.tfhrc.gov/safety/00068.htm>

FDM 11-26-5 Design Process and Qualifications

February 25, 2011

5.1 Roundabout Design Process and Qualifications

Due to modern roundabouts' status as a relatively new and unique design form as well as the inherent complexity of their geometric and operational aspects, WisDOT has developed a roundabout design process and requires that a qualified designer participate in each roundabout design.

This procedure describes the 3-stage design process and the critical design elements. A qualified designer must be involved with each stage of the process. In addition, this procedure describes the various roles the qualified designer may take in completing a roundabout design.

5.2 Roundabout Designer Requirements

A qualified designer must meet the skills, knowledge and experience level determined appropriate by the Wisconsin Department of Transportation for roundabout design. A list of qualified designers for each of the following 3 levels of roundabout complexity is available from the Division of Transportation Systems Development, Bureau of Project Development.

1. Level 1 Roundabout - The design complexity at this level is limited to roundabouts where all legs (not to exceed 4 legs) are single lane entries without bypass lanes. A level 1 designer must have an

understanding of roundabout design with high confidence in designing truck aprons, developing a design with appropriate values for the six geometric parameters, design for appropriate fastest speed paths, design for truck turning paths, have the ability to properly run RODEL and evaluate output from the RODEL software program. The Level 1 qualified designer shall inform the Region when the roundabout design exceeds the complexity stated above for a level 1.

2. Level 2 Roundabout - The design complexity at this level is limited to roundabouts where legs are dual lane entries or less and may have bypass lanes. A level 2 designer must be proficient in roundabout design with ability to design truck aprons, developing a design with appropriate values for the six geometric parameters, design for appropriate fastest speed paths, design for truck turning paths, develop special signing and pavement marking needs, and have the ability to properly run RODEL and evaluate output from the RODEL software program. The Level 2 qualified designer shall inform the Region when the roundabout design exceeds the complexity stated for a level 2. See discussion below about dual lane roundabouts in close proximity and the potential for Level 3 involvement.
3. Level 3 Roundabout - The design complexity at this level involves all roundabout designs to include 3 or 4-lane entries, or has closely spaced roundabouts where the operations of one may have an impact on the operations, signing and/or marking of another. See discussion below about dual lane roundabouts in close proximity and the potential for Level 3 involvement. A level 3 designer must have the skills and knowledge for the most complex roundabout designs.

The Region will use the best traffic data available to select the appropriate qualified designer (Level 1, 2, or 3). This is typically determined prior to project solicitation by the Project Development Section.

The project team will select either a Level 2 or 3 qualified designer if the Region anticipates that the project will include a dual lane roundabout. There are certain situations when it is desirable for the Region to involve a Level 3 qualified design on dual lane roundabout projects. Some examples include situations where:

- There are other multi-lane roundabouts in close proximity.
- Lane assignment and/or lane continuity is difficult to achieve without adding another lane.
- Reduction in weaving between roundabouts is desired.
- Queue backup into an adjacent multi-lane roundabout is probable.
- Other special needs that have been identified.

The Region will discuss the involvement of a Level 3 qualified designer for dual lane roundabout projects to determine if expertise is needed beyond that provided by a Level 2 qualified designer.

WisDOT Regions, consultants, local agencies such as a counties, townships, municipalities, and developers, etc. shall have a qualified designer on staff, or contract with an approved designer, to provide the required sign-off on [Table 5.1](#) for roundabout designs, as described below, for both WisDOT and WisDOT oversight projects.

Qualified designers may participate in different ways in order to provide the required sign-off on [Table 5.1](#).

1. Independently complete the roundabout design. When a WisDOT Region, consultant, local agency such as a county, township, municipality etc. or a developer has a roundabout on a project they must have a qualified designer to oversee or complete all aspects of the plans, specifications and estimate (PS & E) package for the roundabout according to the 3-Stage Design Process described below.
2. Assist and mentor the project team in their completion of the roundabout design. A WisDOT Region, consultant or local agency such as a county, township, municipality etc. or developer has a roundabout on the project may prefer to contract for assistance or mentoring from a qualified designer in the plans preparation process. The qualified designer must directly assist the project team addressing the critical design elements in the 3-Stage Design Process described below.
3. Independently review the roundabout design prepared by a project team. A WisDOT Region, consultant, local agency such as a county, township, municipality etc. or developer has a roundabout on the project and the design is prepared without any assistance from a qualified designer. The roundabout designer is responsible to contract with one of the qualified designers to review the critical elements of the design at each stage of the 3-Stage Design Process described below. The information to be provided to the qualified designer at each stage of plans complete is provided below.

Coordinate the proposed roundabout design with a qualified designer early in the design process. It is better to allow the qualified designer to be proactive and in a position to suggest modifications rather than to be reactive and lose design options because the design or commitments on the project are too far along.

The qualified designer's review comments shall be submitted to the project team and the WisDOT Region at each Stage. The critical design recommendations from the qualified designer should be identified clearly so the

roundabout design team knows what to modify on the plans. Less critical comments will likely improve the design more toward optimal and should not be taken lightly. A discussion between the qualified designer, design team, and Region may be needed to properly address recommendations in the plans or document the dismissal of the comment(s).

The qualified designer in consultation with WisDOT will determine which elements of the design are critical in the situation where a dispute may take place. Department personnel are responsible to ensure that the qualified designer recommendations and comments are properly addressed by the design team.

5.3 Intersection Control Evaluation, Program Level Scoping phase.

For an explanation of the required level of analysis see [FDM 11-25-3](#). The Program Level Scoping phase typically does not yield the final determination on the selected intersection control. However, there are 3 early screening criteria identified in [FDM 11-25-3](#) and evaluated during the Program Level Scoping phase that may eliminate the roundabout from further consideration.

A qualified designer is not required for the Program Level Scoping phase of an Intersection Control Evaluation.

5.4 The 3-Stage Roundabout Design Process

The following information describes each of the stages of development where it is critical to have a qualified designer involved in the roundabout design. There may be a project schedule delay or adverse cost ramifications associated with a roundabout design if each stage of the evaluation is not followed in sequence.

5.4.1 Stage 1, Roundabout Design Process

Prior to 30% plans complete. While the desired type of intersection control may still be undetermined; the roundabout has been identified as one of the viable alternatives from the Program Level Scoping phase. Complete Stage 1, requires qualified designer involvement, prior to the 30% plans complete level so the comments and design adjustments are incorporated and ready with the typical 30% plan review discussion/meeting conducted by the region. For designs prepared outside the Region, submit Stage 1 plans to the Region in .dgn format. Generally, it is preferred to have the roundabout design developed far enough to have an idea of right-of-way needs, raised median locations identified, access, major utilities and other potential impacts prior to a Public Informational Meeting (PIM) so relatively accurate information can be presented and discussed with property owners to include Level of Service (LOS), or delay, comparisons with other intersection control alternatives. There may be situations where the design is accurate and detailed enough showing the proper size and location of the roundabout, LOS, extent of the splitter island curb locations and type of access along the roadway that a more detailed design could be completed after the PIM.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Determine optimum location of circle with inscribed diameter.
2. Use Traffic Flow Worksheet, [FDM 11-26 Attachment 20.3](#). Completed with existing volumes, design year volumes for AM and PM peak and midday if a tourist area that may have higher midday than AM or PM peaks.
3. Establish lane configuration(s).
4. Complete lane markings and pavement arrows for multilane only.
5. Complete a highly developed design that shows face of curb locations, crosswalks, splitter islands, sidewalk or multi-use path, bike ramps, truck apron etc. with appropriate widths.
6. Use RODEL analysis for design with measured design parameters.
7. Verify design vehicle movement checks (WB-65 on STH system).
8. Show the fast path with speed calculations for R1 thru R5.
9. Fill out [Table 5.1](#).
10. Prepare preliminary stopping sight distance for - approach, circulatory roadway, crosswalk and exit, and the intersection sight distance.
11. Prepare preliminary centerline profile of circulatory and approach roadway.
12. Prepare preliminary typical sections on the mainline roadway.

5.4.2 Stage 2, Roundabout Design Process

Prior to 60% plans complete. Complete design revisions recommended by the qualified designer from the

previous 30% design. At this stage a qualified designer is required to complete the design/review of the critical design elements identified below. Prepare the plans such that the environmental documents may be completed, DSR approved and plat work may begin. Complete Stage 2, including all qualified designer involvement prior to the 60% plans complete level so the review comments and design adjustments are incorporated and ready for the Region in preparing for the typical 60% plan review discussion/meeting. For designs prepared outside the Region, submit Stage 2 plans to the Region in .dgn format. At this stage the Qualified designer shall sign [Table 5.1](#) for attachment to the DSR. One of the primary critical elements of design at this stage is the vertical control with each leg having vertical profiles, circulating roadway profile, crown location, slope intercepts, central island grading, drainage consideration with inlet locations, and spot elevations.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Finalize horizontal design changes implemented.
2. Establish roadway profiles on each leg.
3. Establish circulating roadway profile.
4. Show crown location, cross slopes, spot elevations.
5. Consider central island grading design.
6. Consider drainage design/inlet locations.
7. Show preliminary light standard locations.
8. Identify the need for large green and white guide signs, overhead guide signs, or other non-standard installations.
9. Finalize lane marking and lane assignment pavement marking for multilane roundabouts.
10. Identify major utility conflicts (i.e. utility conflicts that may result in relocating the circle).
11. Prepare preliminary typical sections.
12. Consider preliminary construction staging layout and identify potential staging conflicts, such as access control, large grade differences between stages, etc. that may impact the design.

5.4.3 Stage 3, Roundabout Design Process

Prior to 90% plans complete. Finalize the vertical, drainage, pavement marking, signing, lighting, landscaping plans, work zone traffic control, and utility coordination. In preparation for PS & E complete Stage 3, including all qualified designer involvement, prior to the 90% plans complete level so the review comments and design adjustments are incorporated and ready for the region in preparing for the typical 90% plan review discussion/meeting. This is the final design with construction staging or detour plan.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Complete final plan and profile with any vertical and horizontal control details included for field layout.
2. Prepare final signing and pavement marking plan.
3. Prepare final landscaping and lighting plan.
4. Prepare final construction staging plan.

5.5 Roundabout Criteria

For each proposed roundabout, the critical design parameters in [Table 5.1](#), and described above must be provided to the qualified designer at Stage 1 and Stage 2 of project development. The roundabout design process and associated project criteria are explained above. The qualified designer must sign and date [Table 5.1](#) and attach it to the Design Study Report after Stage 2 project complete. (A working version of this table: [FDM 11-26-5, doc1](#))

Table 5.1 Critical Design Parameters

Intersection	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5	Leg 6
Half width, ft, (V=)						
Entry width, ft, (E=) (actual/effective)						
Effective Flare, ft, (L'=)						
Entry Radius, ft, (R=)						
Entry Angle (Phi Ø=)						
R1, Radius/speed						
R2, Radius/speed						
R3, Radius/speed						
R4, Radius/speed						
R5, Radius/speed						
Exit Width						
Stopping Sight Distance						
Intersection Sight Distance						
Inscribed Circle Diameter., ft, =						

Design Vehicle: _____

Circulating Roadway Width: _____

Truck Apron Width, if present: _____

Vertical control has been reviewed & comments provided: Yes or NO (circle one).

Circulating Roadway Cross Slope (Typical section)

Control of Access & Parking near the roundabout: _____

Pedestrian/Bicyclist Accommodations: _____

Reviewers Name:_____ Date:_____. The reviewer's name/signature on this document indicates that the design has been reviewed and is in general compliance with good roundabout principles. The Stage 2 critical design elements have been addressed. The project design engineer in responsible charge of plans development will stamp the plans when applicable.

FDM 11-26-10 Multimodal ConsiderationsFebruary 25, 2011**10.1 Pedestrian and Bicyclist Accommodations**

Accommodating non-motorized users is a Department priority. Therefore, give special consideration to locations where:

- Pedestrian volumes are high
- There is a presence of young, elderly or visually impaired citizens wanting to cross the road
- Pedestrians are experiencing particular difficulty in crossing and being delayed excessively.

Also, consider the adjacent land use near the roundabout location, such as schools, playgrounds, hospitals, and residential neighborhoods. These sites may warrant additional treatments as presented below. Prior to determining whether bicycles and/or pedestrian concerns will be a factor in the design of the roundabout, the designer is strongly encouraged to contact the Region or State Bicycle and Pedestrian Coordinator for their guidance.

10.1.1 Pedestrians

Research conducted in Europe and presented in the FHWA Roundabout Guide [1] indicates fewer pedestrian accidents with less severity occur at roundabout intersections when compared to signalized and unsignalized intersections with comparable volumes. Design principles need to be applied that provide for slow entries and exits for pedestrian safety.

In general, due to relatively low operating speeds of 15 to 20 mph, pedestrian safety is generally better with a roundabout design than with other intersection types. [Table 10.1](#) lists the advantages and disadvantages of roundabouts as related to pedestrians.

Table 10.1 Roundabout Advantages and Disadvantages for Pedestrians

Advantages	Disadvantages
Vehicle speed is reduced as compared to other intersections.	Vehicle traffic is yield controlled so traffic does not necessarily come to a full stop. Therefore, pedestrians may be hesitant to use the cross walk at first.
Pedestrians have fewer conflict points than at other intersections. Pedestrians are responsible for judging their crossing opportunities. This requires more alertness and may be considered an advantage.	May be unsettling to the pedestrian, depending on age, mobility, visual impairments, and ability to judge gaps in traffic.
The splitter island gore allows pedestrians to resolve conflicts with entering and exiting vehicles separately and simplifies the task of crossing the roadway. Crossing is often accomplished with less wait than at signalized intersections.	Pedestrians at first glance may have to adjust to the operation of a roundabout. Part of this adjustment includes the crosswalk location, which is behind the first stopped vehicle or approximately 20 feet from the yield point.

Choosing the appropriate crossing location for pedestrians is a delicate balance between their safety and convenience, and operation of the roundabout. Pedestrians want crossing locations as close to the intersection as possible to minimize out-of-direction travel. The further the crossing is from the roundabout, the more likely that pedestrians will choose a shorter route that may put them in greater danger. Both crossing location and crossing distance are important. Minimize crossing distance to reduce exposure to pedestrian-vehicle conflicts.

In general, locate the pedestrian crossing one car length or approximately 20 feet upstream from the yield point [2003 MUTCD, Section 3B.24]. This helps to reduce decision-making problems for drivers and avoids creating a queue of vehicles waiting to enter the roundabout. However, for pedestrian safety the crossing should not be located too far back from the yield line such that entering vehicle speeds are insufficiently reduced or exiting vehicles are accelerating. It may be appropriate to design the pedestrian crossing at two or three car lengths from the yield point at some multi-lane entries. Make the crossing perpendicular to the direction of traffic on multi-lane entrances and exits to minimize pedestrian travel and exposure time. On single-lane roundabouts it may be appropriate to provide a crosswalk straight through the splitter island.

At roundabouts with high traffic volumes, or where pedestrian volumes are high, the pedestrian crossing could be enhanced with features such as standard crosswalk pavement marking, colored concrete with patterned borders, 6-inches wide if used, 6-inch white crosswalk marking next to colored concrete [2005 Wisconsin MUTCD Supplement, Section 3E.01] light bollards at entries/exits, and activated (push button or automatic detection) warning signals. In areas with very high pedestrian volumes, consider accommodating both users in the same facility with an overpass or underpass. See FHWA Roundabout Guide, Chapter 4, Exhibit 4-7 and Exhibit 4-8 for pedestrian effects on entry capacity. Consult with the Region and State Traffic Engineer, to concur that appropriate treatment is applied.

The greatest challenge lies with the continual movement of traffic, and the inability of some pedestrians to judge gaps in an oncoming travel stream. This is especially true of children, the elderly or the disabled. These types of pedestrians generally prefer larger gaps in the traffic stream, and walk at slower speeds than other pedestrians. In recognition of pedestrians with disabilities, pedestrian crossings at roundabouts should be designed to comply with Americans with Disabilities Act (ADA) mandated accessibility standards. See the FHWA Roundabout Guide, Chapter 5, Section 5.3.3 Pedestrians and 2003 MUTCD, Section 3B.17.

The “pedestrian hybrid signal” sometimes referred to as the HAWK crosswalk signal may be considered where there is an identified or demonstrated need to accommodate the visually impaired. Another option to consider is the Rectangular Rapid Flashing Beacon (RRFB) that is being studied at this time. However, contact the regional traffic operations unit if RRFB’s are being considered to determine if appropriate for the location and if they will be by permit to the community or by WISDOT.

10.1.2 Bicyclists

The experience in other countries with bicyclists at roundabouts has been mixed with regard to safety. The Insurance Institute for Highway Safety reports that roundabouts provide a 10 percent reduction in bicycle crashes at 24 signalized intersections that were converted to roundabouts in the U.S. Multi-lane entry

roundabouts may be more problematic than single lane entries. However, all multi-lane high capacity roundabouts in the U.S. have experienced a good bicycle safety record.

The operation of a bicycle through a roundabout presents challenges to the bicyclist similar to that of traditional signalized intersections especially for turning movements. As with pedestrians, one of the difficulties in accommodating bicyclists is their wide range of skills and comfort levels in mixed traffic. While experienced bicyclists may have no difficulty maneuvering through a roundabout, less experienced bicyclists may have difficulty and discomfort mixing with vehicles, and are more safely accommodated as pedestrians on the adjacent shared use path. The complexity of vehicle interactions within a roundabout could leave a cyclist vulnerable, and for this reason, designated bike lane markings within the circulatory roadway shall not be used [2003 MUTCD, Section 3B.24]. Effective designs that constrain motorized vehicles to speeds more compatible with bicycle speeds, around 15 – 20 mph, are much safer for bicyclists.

Design features such as proper entry curvature, and entry width help to slow traffic entering the roundabout. Providing a ramp from the roadway to a shared-use path prior to the intersection allows a bicyclist to exit the roadway and proceed around the intersection safely through the use of cross walks if the bicyclist is uncomfortable mixing with vehicles.

Bicyclists are often less visible and therefore more vulnerable when merging into and diverging from multilane roundabouts. Therefore, it is recommended that a wider shared-use pedestrian-bicycle path, separate from the circulatory roadway, be built where bicycle use is expected. While this will likely be more comfortable for the casual bicyclist, the experienced commuter bicyclist will be slowed down by having to cross as a pedestrian at the cross walk and may choose to continue to traverse a multilane roundabout as a vehicle.

Try to provide bicyclists the choice of proceeding through the roundabout as either a vehicle or as a pedestrian. In general, bicyclists are better served by being treated by roundabout designers as vehicles. However, when entering traffic volumes are projected to be large (i.e., greater than 12,000 AADT), look at other options such as shared-use paths, which provide a physical separation from vehicles around the periphery of the roundabout.

The following guidance is intended for shared-use paths at roundabouts.

1. Construct a widened sidewalk, or separate shared-use path around the outside of a roundabout to accommodate bicyclists who prefer not to travel through the roundabout.
2. Begin and end the shared-use path approximately 50 to 150 feet upstream of the yield point to allow the bicyclist an opportunity to transition onto the path away from the circulatory roadway itself. More room may be needed when a flared entrance is provided.
3. Right turn free flow lanes for vehicles may be problematic for bicyclists so try to avoid them if possible in high bicycle areas.
4. Provide a ramp or other suitable connection between this sidewalk or path and the bike lane, shoulders or road surface on the approaching and departing roadway. Show the bike exit ramp generally having a 25 to 35 degree departure angle range from the roadway. Show the bike entrance ramp generally having a 25 to 35 degree angle range toward the roadway. Also see [FDM 11-26 Figure 1.1](#). The bike ramp entrance should be relatively flat such that bicyclists are not directed into the travel lane of motorized vehicles but not parallel to the bike lane.
5. Make the shared-use path or sidewalk the same width as an attached multi-use path or, when not connected, maintain a minimum of 8 feet. A 6-foot wide path may be acceptable if pedestrian use is very low. The shared use path pavement design should consider the type of maintenance equipment used for snow removal.
6. Review the 1999 AASHTO Guide for Development of Bicycle Facilities, page 64, and the Wisconsin Bicycle Facility Design Handbook or consult with the Region or State Bicycle and Pedestrian Coordinator for more detail on the design requirements for bicycle and shared-use path design.

Grade Separation (overpasses or underpasses) for bicyclists may be considered for high-capacity roundabouts, with high bicyclist volumes. For information on permanent public trails crossing rural public roads refer to [FDM 11-55-15](#).

10.2 Transit, Large Vehicle and Emergency Vehicle Considerations

10.2.1 Transit

Transit considerations at roundabouts are similar to those for any other intersection configuration. A properly designed roundabout will readily accommodate buses. If possible, locate bus stops downstream of the roundabout and far enough away to prevent traffic from backing up into the roundabout. Coordinate bus stop locations with the community. Provide bus pullouts, if possible, to remove the buses from the traffic stream.

10.2.2 Large and Oversized Overweight (OSOW) Vehicles

Review the truck guidance provided in [FDM 11-25-1](#), Part 1.1, which is not roundabout specific. However, it includes additional information related to truck routes, the OSOW Freight Network and intersection design guidance. The Department produced a map showing designated state and federal truck routes in Wisconsin which is available on the web, see the link in [FDM 11-25-1](#). The OSOW Freight Network map is available from the Regional Freight Operations Unit. This information is in draft condition and may experience updates and changes in the near term. Therefore this document should not be shared with others unless they are working on projects that include the OSOW Freight

Design roundabouts for the largest vehicles that can routinely be anticipated. On the state trunk highway system the design vehicle is a WB-65. It is also important to consider the OSOW Freight Network in highway design as noted above. During the preliminary design, check with local officials and the public to determine if there are any special OSOW vehicles that regularly use the route and refer to the WisDOT OSOW vehicle inventory in [FDM 11-25 Attachment 1.3](#). Coordinate OSOW Freight Network and routing activities with the Regional Freight Operations engineer.

Roundabouts are designed with a truck apron to accommodate wheel off-tracking of larger vehicles. Multilane roundabouts can be designed in two different ways to accommodate legal size large trucks. One way to design a multilane roundabout is to assume a truck will use two lanes by encroaching into the adjacent lane at entry, and encroach into an adjacent lane to circulate and exit the roundabout. Alternatively, a roundabout can be designed so that trucks can remain in-lane at entry by providing a separation, or gore area, between lanes. A few roundabouts are designed to not only allow a large legal semi to stay in-lane at entry but also stay in-lane while on the circulating roadway. Designing a roundabout for a large legal semi to stay in-lane at entry and within the roundabout presents challenges such as the possibility of a larger diameter, wider entries, potentially increased ROW needs, may lead to increases in certain types of crashes, or other unique design features and is less commonly used. In rare cases, roundabouts have been designed with a gated bypass roadway for turns. It is becoming somewhat common to widen the truck apron along the sides for a through movement to accommodate OSOW vehicles.

A well-designed roundabout will address load-shifting problems with larger vehicles. Problems such as inadequate entry deflection leading to high entry speeds, long tangents leading into tight curves, sharp turns at exits, excessive cross slopes, and adverse cross slopes have been the principal causes of load shifting. Right turns are also problematic for trucks, as they tend to run over sidewalks and splitter islands to make the turn.

10.2.3 Emergency Vehicles

Emergency vehicles passing through a roundabout encounter the same problem as other large vehicles and may require the use of a traversable truck apron. On emergency response routes, compare the delay for the relevant movements with alternative intersection types and controls.

Roundabouts provide the benefit of lower vehicle speeds, which may make them safer for emergency vehicles to negotiate than conventional intersections.

The Wisconsin Motorist's Handbook provides information on what to do when the driver encounters an emergency vehicle. The driver must yield the right-of-way for emergency vehicles using a siren, air horn or a red or blue flashing light. The driver in the circulatory roadway should exit the roundabout before pulling over if possible. Emergency vehicles will typically find the safest and clearest path to get through an intersection. This may include driving the emergency vehicle, with caution and with lights and siren on, in the opposing lane(s) or however the operator sees as the most desirable alternative path.

10.3 References

- [1] "Roundabouts: An Informational Guide," Publication No. FHWA-RD-00-067, June 2000

FDM 11-26-15 Agency and Public Coordination

[February 25, 2011](#)

15.1 Public Awareness

The success or failure of a project can often be attributed to how well the Department included the public in its development. This can be particularly true when introducing the modern roundabout because of its confusion with past circular intersections. There are several excellent resources to assist the designer in explaining the concept to the public.

Concept acceptance and project buy-in are best achieved when the local community has been involved from beginning of the project. Take as many opportunities as possible to explain the project. Public meetings are good places to start and continue to build project support.

Inform the public of advantages and disadvantages of a proposed roundabout. As with any new concept, the project team can anticipate a certain degree of skepticism about a proposed roundabout. It may be viewed as the traffic circle of the past; at best not seen as an improvement, at worst associated with poor operational characteristics. Early public education is essential to a successful project start up. Several educational tools and media are available to help designers inform the public about roundabouts, and build support for the concept. There are brochures, videos, and simulation software available that demonstrates the characteristics of roundabout operations. At times, a local newspaper may be looking for general interest articles; this may be an opportunity to increase public awareness of roundabouts. The WisDOT roundabout web site is another source of current information and frequently asked questions regarding modern roundabouts. The site address is

<http://www.wisconsinroundabouts.gov>

Include state and local politicians, state and local police, local fire and emergency services personnel, maintenance personnel, local trucking companies, elementary and high schools, and any special interests in the awareness process as may exist due to project location.

Typically in the project process, alternatives are considered. The alternatives generally include traffic signal, stop sign, or roundabout control; some of which are familiar to drivers and pedestrians. Presenting a comparison of traffic operations and safety between alternatives is a good way to introduce roundabouts. It is also beneficial to inform the public of good nearby design examples.

15.2 Public Meetings

Public meetings provide an excellent opportunity to bring the public into the design process. It is generally desirable to take the 30% preliminary plan to a public meeting and explain that a roundabout appears to be a reasonable alternative. Try to be as specific as possible about the real estate impacts, access impacts and anticipated operations (LOS) between the various alternatives. At this level of design it may be important to let the public know that you do not have all the answers about the various impacts. Roundabouts are a new form of intersection control that most people are not familiar with. Set a specific time at each PIM of approximately 10-20 minutes to explain the concept of roundabouts and why the Department has included the roundabout as an alternative. Also, illustrate to the public how pedestrians, bicyclists, and vehicles should travel through the roundabout. Holding an open house and public information “exchange” meetings, and attending village and town board meetings or local service organizational meetings are good formats for education and consensus building.

15.3 Informational Brochures, Videos, and Web Site

Informational brochures are a very useful way to educate the public about roundabouts. Not only can they explain the roundabout concept, its advantages and disadvantages, but they can also be used to compare roundabouts to older circular intersection concepts and traditional intersection types. They can also include graphics or photographic images to assist in demonstrating technical issues to non-technical audiences. Wisconsin has developed the “All About the Roundabout” video, interactive animation video and many brochures. The site address is: <http://www.wisconsinroundabouts.gov>

Contact the Bureau of Project Development for additional information. Driver education is provided in the Wisconsin Motorist’s Handbook published by WisDOT.

Designers are encouraged to place project site-specific materials on the WisDOT web site. Coordination of this effort must be through the Central Office (IT) Coordinator and the Web Site Content Coordinator.

15.4 Social, Environmental, and Economic Considerations

Public acceptance of roundabouts can be one of the biggest challenges facing a jurisdiction that is planning to install its first roundabout. Without the benefit of explanation or first-hand experience, the public is likely to incorrectly associate roundabouts with older, nonconforming traffic circles that they have either experienced or heard about. Equally likely, without adequate information the public (and agencies alike) will often have a natural resistance to changes in their driving behavior and driving environment.

Public receptivity can be improved by informing the public about the safety and operational benefits of roundabouts.

Impacts on historic and cultural resources need to be considered especially when a roundabout is proposed for an existing urban area. Public participation and coordination with the State Historic Preservation Office is necessary.

Impacts on visual resources can be a serious issue as well. However, the roundabout offers an excellent opportunity for enhancing the visual environment since the interior of the circle can be landscaped to become an attractive local feature. Also the potential adverse visual impact of signal poles is avoided with a roundabout solution. Public support can be encouraged if the local community can see the roundabout as a visual

enhancement. With regards to noise, energy consumption and air pollution, the modern roundabout offers distinct advantages over other intersection types. Vehicles can create significant air and noise pollution while idling and accelerating through an intersection. On the other hand, vehicles are generally kept moving at lower speeds through a roundabout resulting in less fuel consumption and less air and noise pollution.

There is a socio-economic cost, or cost to society, as a result of crashes that should not be over looked. The cost of a crash is difficult to quantify with a specific value for every situation. The National Safety Council, (NSC) "Estimating the Cost of Unintentional Injuries, 2008"

http://www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx also has calculated the costs of motor-vehicle crashes that may be used to estimate the impact on the economy. The costs are a measure of the dollars spent and income not received due to crashes, injuries, and fatalities shown in [Table 15.1](#).

Table 15.1 Crash Cost by Injury Type (2008 Dollars) [1,2,3]

Crash Injury Type	Comprehensive Cost	Economic Cost
Fatality	\$4,200,000	\$1,300,000
Incapacitating Injury	\$214,200	\$63,500
Non-Incapacitating Injury	\$54,700	\$21,800
Possible Injury	\$26,000	\$12,300
Property Damage	\$2,400	\$8,300

Construction cost is always a major factor in every project. It is important to understand that there is also a cost to society for the crashes experienced on our highways. It is in the best interest for the citizens of a community to consider all the costs of a proposed intersection control to include crash cost, construction cost, engineering cost, maintenance cost, and delay cost associated with the selection of the intersection control. The National Safety Council and literature review suggest that comprehensive crash costs be used for all benefit-cost analysis [1,2,3].

The Highway Safety Improvement Program (HSIP) uses significantly different values than those shown in [Table 15.1](#) to evaluate, identify and prioritize crash problem locations that are eligible to receive HSIP funding.

Pavement life-cycle cost and benefit is discussed in [Chapter 14](#).

15.5 References

- [1] National Safety Council. Estimating the Costs of Unintentional Injuries, 2008. National Safety Council Website. http://www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx
- [2] Boardman, A., Greenberg, D., Vining, A., and Weimer, D. *Cost Benefit Analysis: Concepts and Practice*. Prentice Hall; 3rd Edition, 2005.
- [3] Gómez-Ibáñez, J. A., Tye, W. B., and Winston, C. *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Mayer*. Brookings Institution Press, 1999

FDM 11-26-17 Access Control

April 30, 2008

17.1 Access Management

Management of access to arterial roads is vital to creating a safe and efficient transportation system for motorists, bicyclists, and pedestrians. Access guidance is provided through the Region access coordinator, [Chapter 7](#) of the Facilities Development Manual (FDM), and the WisDOT Traffic Impact Analysis (TIA) Guidelines..

The operational characteristics of roundabouts may offer advantages when compared to existing conventional approaches to access management. Some roundabout benefits include:

- Increased capacity along arterial roads,
- Reduction of traffic congestion and delay,
- Improved safety,
- More efficient use of land, and
- Savings on infrastructure investments

For example connecting two roundabout intersections with a raised median will preclude lefts in/out from the side street or business access to protect main-line capacity. U-Turns are not problematic at roundabouts and can increase safety. This provides the desired capacity protection and safety along the mainline with less impact to business accessibility.

Major commercial driveways may be allowed as one leg of the roundabout. However, installation of a signal or roundabout strictly for access to private development is discouraged. They may be designed at a public road access point as an intersecting leg of a roundabout. Moreover the roundabouts may reduce the need for additional through-lanes thus narrowing the overall footprint of the roadway system.

Minor commercial and residential driveways are not recommended along the circulating roadway unless designed as a leg of the roundabout. Some situations may dictate the need for a driveway and must be analyzed on a case-by-case basis. Driveways may be located along entrances and exits, but need to be set back to not interfere with pedestrian movements in the crosswalks, and to minimize the number of conflict points with vehicles approaching or exiting the roundabout

The preliminary planning phase for any intersection including roundabouts should include a comprehensive access management plan for the site. Consider the possible need to realign/relocate existing driveways, and include their associated costs in the project's preliminary estimate. Account for pedestrian accessibility and safety during all stages in the development of a comprehensive access management plan.

17.2 Functional Intersection Area

As addressed in [FDM 11-25-1](#) the functional area of an intersection includes the physical area, but also extends upstream and downstream, along all of the intersection roadways, from the physical area. The functional area for a roundabout is generally less restrictive due to low speeds (15 to 20 mph) and less queuing, when compared to a traditional signalized intersection. Roundabouts will reduce queuing and minimize the need for exclusive turning lanes that may be required at a signalized intersection. Also different sight requirements at a roundabout require drivers to judge gaps at higher perception reaction time (PRT) than stated in [FDM 11-25, Table 1.1](#). A roundabout's functional intersection area should be determined by the length of the splitter island and the estimated queue length back from the yield line. Use the RODEL software to analyze the length of queue as discussed in [FDM 11-26-20](#). Also, consider the sight distance and high speed approach requirements discussed in [FDM 11-26-30](#).

17.3 Corner Clearance and Driveway Location Considerations

Corner clearance represents the distance that is provided between an intersection and the nearest driveway. [FDM 11-25-1](#) discusses the four types of corner clearance and corner clearance distances for State Trunk Highways (STHs). Corner clearance for roundabouts is generally less restrictive than a signalized intersection because a roundabout reduces speed and queuing. On a case by case basis it may be feasible to consider full access driveway closer to a roundabout than would be considered for other types of control, e.g. a traffic signal. There are three main considerations for driveway location relative to a roundabout entry or exit:

1. Volume of the driveway: If it is only occasional traffic and off-peak hour, entering the driveway from the highway, i.e. a low volume case, there may be no storage required for left turns. The driveway may be located closer to the roundabout subject to criteria 2 and 3. If the volume entering the driveway from the highway is moderate and the arterial flow impeding the driveway results in a predicted queue spillback then the queue length must be accounted for in the driveway location. In cases where a driveway location is downstream of a roundabout exit there is a potential for the left turning traffic to back up into the roundabout.
2. Operational impacts of the roundabout (queue spillback from the entry across the driveway opening): From the queue prediction results generated from RODEL the designer can assess how often the entry will queue back across the driveway.
3. Sight distance between users: The driveway exit must have proper sight distance of the roundabout exit, the speed of exiting traffic from the roundabout and to the left of the approaching upstream traffic. The approach sight to the driveway from the roundabout or approaches to the roundabout must also meet intersection sight criteria for the approach speeds.

17.4 Interchange Ramps

According to [FDM 11-5-5](#) a minimum distance of 1320 feet between a ramp terminal and any adjacent intersection is required. This distance (1320') is typically needed to provide progression for a series of signalized intersections. Roundabouts need less space between adjacent intersections to operate at a high level of service. Operational concerns at an interchange resulting from reduced access spacing, such as traffic blocking adjacent intersection, can be better understood through the analysis of forecasted queue lengths. Queue

lengths for a roundabout should be predicted with the use of RODEL traffic modeling and the impacts to the adjacent intersections reviewed using other appropriate traffic modeling software. A traffic analysis is required to justify a less than desirable distance (1320 feet) of access control.

FDM 11-26-20 Operations

February 25, 2011

20.1 Design References and Methods

The Federal Highway Administration (FHWA) has published a design guide for roundabouts [1]. The guide, "Roundabouts: An Informational Guide," is available at <http://www.fhrc.gov/safety/00068.htm>. This document is an informational guide and is not intended to be an inflexible "rule book" but rather it attempts to explain some principles of good design and indicate potential tradeoffs.

There have been multiple studies on the use, effectiveness and safety of roundabouts. One such study was conducted by researchers at Ryerson Polytechnic University and the University of Maine.

20.2 Roundabout Operation

A roundabout brings together conflicting traffic streams, allows the streams to safely cross paths and traverse the roundabout and exit to their desired directions at reduced speeds. Modern roundabouts do not have merging or weaving between conflicting traffic streams. Compactness of circle size and geometric speed control make it possible to establish priority to circulating traffic. The geometric elements of the roundabout reinforce the rule of circulating traffic priority and provide guidance to drivers approaching, entering, and traveling through a roundabout.

Drivers approaching a roundabout must slow to a speed that will allow them to safely interact with other users and negotiate the roundabout. The width of the approach roadway, the curvature of the roadway, and the volume of traffic present on the approach govern this speed. As drivers approach the yield point, they must first yield to pedestrians and then to conflicting vehicles already in the circulatory roadway. The widths of the approach roadway and entry determine the number of vehicle streams that may form side-by-side at the yield point and govern the rate at which vehicles may enter the circulatory roadway. The size of the inscribed circle affects the radius of the driver's path, which in turn determines the speed at which drivers travel in the roundabout. The width of the circulatory roadway determines the number of vehicles that may travel side-by-side in the roundabout.

20.2.1 Space Requirements and Capacity Limitations

The inscribed circle diameter needed for a roundabout is one of the most critical space requirements when considering impacts. The following table gives general inscribed circle diameters and daily service volumes for the different WisDOT categories of roundabouts. Use [Table 20.1](#) for inscribed circle diameter values to help in the roundabout analysis. Diameters will vary and may fall outside these prescribed ranges in some situations. [Table 20.1](#) also provides a rough estimate of capacity for the WisDOT roundabout categories.

Table 20.1 Typical Inscribed Circle Diameters and Daily Service Volumes

Roundabout Type	Typical Inscribed Circle Diameter ¹	Typical Daily Service Volume ² (vpd) 4-leg roundabouts
Urban Single-Lane	120 - 150 ft (35 – 45 m)	less than 25,000
Urban Multilane (2-lane entry)	160 - 215 ft (50 – 65 m)	25,000 to 55,000
Urban Multilane (3 or 4-lane entry)	215 - 275 ft (65 – 85 m)	55,000 to 80,000
Rural Single-Lane	130 - 150 ft (40 – 45 m)	less than 25,000
Rural Multilane (2-lane entry)	165 - 215 ft (50 – 65 m)	25,000 to 55,000
Rural Multilane (3-lane entry)	215 - 300 ft (65 – 90 m)	55,000 to 70,000

¹ The diameters provided are for general guidance.

² Capacities vary substantially depending on entering traffic volumes and turning movements.

20.3 Roundabout Capacity

The capacity of each entry to a roundabout is the maximum rate at which vehicles can reasonably be expected to enter the roundabout during a given time period under prevailing traffic and roadway (geometric) conditions.

An operational analysis considers a precise set of geometric conditions and traffic flow rates defined for the design hour volume (DHV) for each roundabout entry. Analysis of the peak hour period is critical to assess the level of performance of the roundabout and its individual components. The capacity of the entire roundabout depends on many factors. In each case, the capacity of an entry or approach is computed as a function of traffic on the other (conflicting) approaches, the interaction of these traffic streams, and the intersection geometry.

For a properly designed roundabout, the yield point is the relevant point for capacity analysis. The approach capacity is the capacity provided at the yield point. This is determined by a number of geometric parameters in addition to the entry width. On multilane roundabouts, it is important to balance the traffic use of each lane otherwise some lanes may be overloaded while others are underutilized. Also, poorly designed exits may influence driver behavior and cause lane imbalance and congestion at the opposite leg.

The maximum flow rate that can be accommodated at a roundabout entry depends on two factors: the circulating flow in the roundabout that conflicts with the entry flow, and the geometric elements of the roundabout. When the circulating flow is low, drivers at the entry are able to enter the roundabout without significant delay. The larger gaps in the circulating flow are more useful to the entering drivers and more than one vehicle may enter each gap. As the circulating flow increases, the size of the gaps in the circulating flow decreases, thus the rate at which vehicles can enter also decreases.

The geometric elements of the roundabout also affect the rate of entry flow. The most important geometric elements are the width and number of lanes at entry, and the circulatory roadway width within the roundabout. Two entry lanes permit nearly twice the rate of entry flow compared to one lane. A wider circulatory roadway allows vehicles to travel side-by-side or staggered, which creates a tighter group of vehicles, thereby providing longer gaps. The effective flare length can substantially increase capacity while the inscribed circle diameter and entry angle (ϕ) generally have minor effects on capacity.

20.3.1 Single-lane Roundabout Entry Capacity

Roundabout capacity is site specific since it is related to the geometric features of each site. For planning purposes, single-lane roundabouts can be expected to handle an AADT of approximately 25,000 veh/day(vpd) and peak-hour flows between 2,000 vph and 2,500 vph. This rate exceeds 1,900 vph, which is the typical single-lane capacity of a signalized intersection (reported in passenger car equivalents per hour of green time per lane; 2000 Highway Capacity Manual, Chapter 16). This higher rate is achieved for several reasons. First, this is the total of all the approaches, where this is typically two approaches for signalized intersections. Second, because of multiple approaches and right turns, much of the traffic does not conflict and may enter the intersection simultaneously.

20.3.2 Single Lane Exit Capacity

It is difficult to achieve an exit flow on a single lane of more than 1,400 vph, even under good operating conditions for vehicles (i.e., tangential alignment, and no pedestrians and bicyclists). Under normal urban conditions, the exit lane capacity will be in the range of 1,200 vph to 1,300 vph. Therefore, exit flows exceeding 1,200 vph may indicate a lower LOS or the need for a multilane exit.

20.3.3 Multilane Roundabout Capacity

For planning purposes, multilane roundabouts (two- and three- lane entries) can be expected to handle AADTs between 25,000 and 55,000 vpd and peak-hour flows between 2,500 vph and 5,500 vph. The expected capacity can be even higher with the use of by-pass lanes.

20.3.4 Pedestrian Effects on Entry and Exit Capacity

Pedestrians crossing at a marked crosswalk that has priority over entering motor vehicles can have a significant effect on the entry capacity. In such cases, if the pedestrian crossing volume and circulating volume are known, multiply the vehicular capacity by a factor M according to the relationship shown in Exhibit 4-7 or 4-8 of the FHWA Roundabout Guide for single-lane and double-lane roundabouts, respectively. Note that the effects of conflicting pedestrians on the approach capacity decrease as conflicting vehicular volumes increase, as entering vehicles become more likely to have to stop regardless of whether pedestrians are present. Consult the Highway Capacity Manual for additional guidance on the capacity of pedestrian crossings if the capacity of the crosswalk itself is an issue. A similar concern may occur at the roundabout exit where pedestrians cross.

20.4 Operational Analysis Tools

Roundabout intersection analysis models generally fall into two categories. Empirical models rely on field data to develop relationships between geometric design features and performance measures such as capacity and delay. Analytical models are based on the concept of gap acceptance theory. Extensive research [3], [4], [5], [6] conducted in England supports the empirical formula method of roundabout analysis over the gap acceptance method of analysis. RODEL and ARCADY are software programs that are based on this research and the

empirical formula method. RODEL permits the designer to quickly and easily test “what-if” scenarios, thus allowing designers to optimize their design rather than just settle on the one that meets minimum criteria. This is important as small changes in roundabout geometry such as entry width or flare length may increase the probability that the roundabout will perform well at high v/c ratios. Therefore, the Department requires the final analysis of the roundabout design and operation to be conducted using RODEL. RODEL is available from:

RODEL Software
Marcus House, Park Hall Business Village
Stoke on Trent ST3 5XA
United Kingdom
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The current RODEL manual is available at (<http://dotnet/dtsd/manuals/docs/rodelmanual.pdf>) for WisDOT staff.

20.5 Key Roundabout Parameters Affecting Operating Capacity

The key roundabout design parameters are shown in [Attachment 20.1](#) and defined in the accompanying table.

This figure provides a description of key roundabout design parameters with dimensions shown in metric. Metric dimensions are used because the RODEL software, at this time, will accept only metric units. Plan sheet values shall show US Customary units. In preliminary design there may be rounding of the metric values to achieve even foot dimensions for inscribed diameter, lane width, circulatory roadway width or effective flare length or other dimensions if desired.

[Attachment 20.2](#) shows typical relationships between the six geometric design parameters and roundabout capacity. [Figure 20.1](#) shows that the inscribed circle diameter typically has less impact on roundabout capacity than entry width, flare length and entry radius.

British research indicates that approach width, entry width, effective flare length, and entry angle have the most significant effect on entry capacity. When circulating flows are high, increasing the inscribed circle diameter (ICD) will substantially increase capacity. [Figure 20.1](#) shows that the capacity on one leg of the roundabout is increased by 401 vehicles per hour when the ICD is increased from 130 ft to 195 ft. This increased capacity can happen on more than one leg.

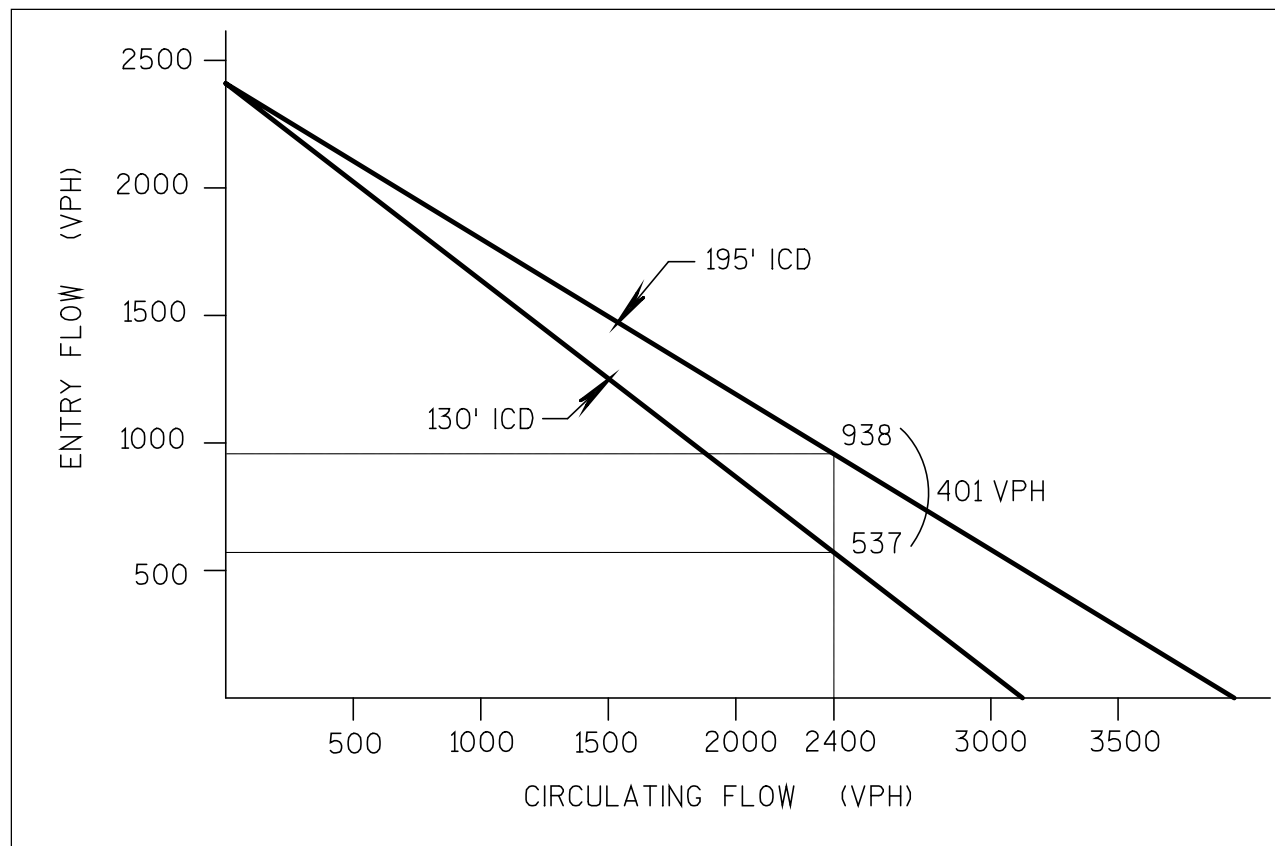


Figure 20.1. Capacity vs. Inscribed Circle Diameter

The entry radius has little effect on capacity provided that it is 65 feet or more. Using an entry radius significantly lower than 45 ft reduces capacity with increasing severity. A small entry radius tends to produce large entry angles and the converse is also true. Perpendicular entries (70 degrees or more) and small entry radii (less than 50 feet) will reduce capacity, therefore do not use these values. The RODEL model described in the following section allows designers to perform sensitivity analysis by manipulating geometric design elements to determine the operational effects of these elements on their designs. Thus, the geometric elements of a roundabout, together with the volume of traffic desiring to use a roundabout at a given time, determine the efficiency of roundabout operation.

20.6 Rodel Software

RODEL is based on the above described empirical relationships that directly relate capacity to both traffic characteristics and roundabout geometry. The empirical relationships reveal that small changes in the geometric parameters produce significant changes in capacity. For instance, if the approach is flared, additional capacity will be provided. Flaring the approach from one lane to two lanes can nearly double the approach capacity, without requiring a two-lane roadway prior to the roundabout. A flared entrance is designed to have equal width and taper and there is equal lane length. Wider entries require wider circulatory roadway widths. This provides more opportunities for the circulatory traffic to bunch together, thus increasing the number of acceptable gaps for vehicles to enter the roundabout. Only a small number of vehicles may be able to enter into an acceptable gap in the circulating traffic. Because drivers frequently use short lanes to reduce the queue length, short lanes can be very effective at increasing vehicle group sizes and the resultant increase in roundabout capacity.

RODEL is a fully interactive program for aiding roundabout design. The purpose of RODEL is to:

1. Improve design quality and operational efficiency
2. Reduce design time
3. Reduce land costs
4. Allow rapid exploration of many options
5. Derive the optimum layout within the conflicting constraints of cost, delay and safety.

Rather than simply checking designs after they have been drawn, RODEL generates geometry prior to

preliminary design. This avoids the time consuming practice of repeated designing and checking. The program operates in two modes:

1. Mode 1 can be used to help generate a set of minimum and maximum entry and effective flare combinations for each leg that are equivalent to target parameter inputs entered by the user. There are four different target parameters that can be chosen in mode 1; average delay, maximum delay, maximum queue and maximum v/c ratio. The user can use one of these target parameters to help fit the roundabout to the site constraints in the AM and PM peak traffic periods. Sets of entry geometry are generated for each approach. Mode 1 is rarely used because most designers use default geometry to initially size roundabouts.
2. Mode 2 is used to refine the Mode 1 results or the default geometry provided in [Table 20.3](#). Mode 2 uses a flow and capacity factor on each leg for a check of sensitivity and design robustness. The simultaneous display of input and output allows the selected geometry to be repeatedly modified and refined. The resulting queues and delays are displayed every 1 or 2 seconds enabling the designer to develop a "feel" for the design and to converge on a preferred layout within the constraints. It is recommended that designers use Mode 2 with the default values provided in [Table 20.3](#). Further information on the RODEL modes is available in RODEL Interactive Roundabout Design Manual.

RODEL achieves balanced designs by means of the Flow Factor. When an acceptable set of geometry has been found in conjunction with cost and delay characteristics, the Flow Factor can be used to increase the flows on all legs incrementally. Usually one leg fails well before the rest. Minor changes in the geometry can improve the worst leg at the expense of the better legs to derive a balanced design that should perform equally well on all legs.

It is essential that the geometry used in RODEL is the 'EFFECTIVE GEOMETRY' otherwise the actual queues and delays will be considerably greater than the RODEL results. This is particularly true for the Entry Width E, the Entry Lane Markings and signs, the Flare Length L', and the Exit Geometry.

20.6.1 Entry Width

The empirical capacity equations reveal that capacity is very sensitive to the entry width. The effective entry (default values used for RODEL, [Table 20.2](#)) width is often less than the physical entry width (typical design values, [Table 20.3](#)), particularly for single lane roundabouts that provide for large trucks needing wide entries but still operate as single lane roundabouts. Because capacity is so sensitive to the entry width, this can lead to a severe under estimation of queues and delays.

Entry width and circulating width are measured between curb faces. A single lane entry width is sometimes widened to provide space for truck turning movements. When widening a single lane entry the capacity increases due to three mechanisms. First the side friction is reduced. Second a staggered or "zippered" queuing on either side of the lane takes place which reduces the follow time of vehicles. Third doubling of vehicles at the yield line starts and occurs increasingly as the lane widens.

The third, and in some ways the second will not occur if the circulating width of the roundabout is a single lane. These effects would require a circulating width of at least two lanes. Unfortunately, RODEL cannot differentiate between these options because a circulating width is not entered into the program. Thus, RODEL assumes the entry width corresponds to the correct circulating width. At 6.0m RODEL treats the entry as two 3.0m lanes. Consequently, effective entry widths greater than 4.3m or 14 ft should not be entered into RODEL for a single lane entry unless it feeds a two lane circulating roadway even if the design width is wider to accommodate trucks. Do not use entry width greater than 8.0 m for dual lane entries or more than 12.0 m for triple lane entries. The default values input into RODEL may differ from the actual design geometrics values.

[Table 20.2](#) provides default RODEL parameters for single lane, dual lane and triple lane roundabouts. Note, these parameters will not always match design values shown in [Table 20.3](#).

Table 20.2 Rodel - Default Geometric Parameters

Geometric Parameters ^A	Single-Lane Entry	Dual-Lane Entry	Triple-Lane Entry
Entry Width (E) ^B	4.0-4.3 m (13-14 ft)	6.7-8.0 m (22-26 ft)	9.75-12.0 m (32-39 ft)
Effective Flare Length (L') ^B	40 m (130 ft)	40 m (130 ft)	40 m (130 ft)
Half Width (V) ^B	3.65 m (12 ft)	7.30 m (24 ft)	10.95 m (36 ft)
Entry Radius (RAD)	20 m (65 ft)	20 m (65 ft)	20 m (65 ft)
Entry Angle (phi)	25	25	25
Inscribed Diameter (DIA)	45 m (150 ft)	50 m (165 ft)	65 m (215 ft)
Grade Separation (GRAD SEP)	0 or 1	0 or 1	0 or 1

^A At this time RODEL works only with metric values

^B High influence on capacity

Table 20.3 Typical Range of Design Values

Geometric Parameters	Single-Lane Entry	Dual-Lane Entry	Triple-Lane Entry
Entry Width (E)	18-22 ft (5.5-6.7 m)	24-28 ft (7.3-8.5 m)	34-40 ft (10.4-12.2 m)
Effective Flare Length (L')	15-300 ft (5-100m) if needed for capacity		
Half Width (V)	Traveled lane width approaching the roundabout prior to any flared section (paint to paint distance)		
Entry Radius (RAD)	55-90 ft (17-27 m)	55-100 ft (17-30 m)	65-100 ft (20-30 m)
Entry Angle (phi)	16-30	16-30	16-30
Inscribed Diameter (DIA)	120-150 ft (35-45 m)	150-215 ft (50-65 m)	200-300 (60-90 m)
Circulatory Roadway Width	Typically 1.0 to 1.2 times the width of the widest entry into the roundabout		
Exit Radius	Exit curves should be larger than entry curves and typically have R3 speeds higher than the R2 speed (Range 200-1000 ft)		

20.6.2 Roundabout Performance Measures

Two measures are typically used to estimate the performance of a given roundabout design: delay, and queue length. Each measure provides a unique perspective on the quality of service of a roundabout under a given set of traffic and geometric conditions. Delay is a standard parameter used to measure the performance of an intersection or approach. The Highway Capacity Manual identifies delay as the primary measure of effectiveness for both signalized and un-signalized intersections, with level of service determined from the delay estimate. RODEL determines the average and maximum delay in seconds for each approach at a roundabout, as well as the roundabout's overall average delay. This overall average delay is used in determining the roundabout's level of service (LOS).

The delay and LOS values provided by RODEL are based on total delay, which is similar to other highway capacity software. However, the delay thresholds used by RODEL to define LOS do not always correspond to the Highway Capacity Manual thresholds. The LOS values in RODEL may be modified to match the Highway Capacity Manual in the RODEL folder file called LOSDATA using MS Word or Notepad. For similar delay values, RODEL typically assigns a worse LOS. The 50 percent confidence level (CL) is the industry standard for software evaluating capacity, delay and queuing. The default CL for RODEL is also 50 percent, but the 85th percentile CL is always tested to review the sensitivity of the design. See [FDM 11-26-50](#), Section 5 for additional information on stop delay verses total delay and comparing signal delay to roundabout delay.

Queue length is important when assessing the adequacy of the geometric design of the roundabout approaches. RODEL calculates an average and maximum queue for each approach in number of vehicles. The approach roadway should have adequate storage capacity so the queue does not obstruct driveway access or another intersection. Depending on location, a queue of 10 vehicles may be unacceptable at one site while a queue of 50 vehicles at another site may not present a problem. The RODEL queue length is the mean of the random queue length distribution. The random 95% queue is about two times the RODEL queues. If the roundabout is operating well with RODEL set at the 85% capacity confidence level, then the 50% queue lengths will be small. See [FDM 11-26-50](#), Section 7 "Maximum Queue" for additional information.

20.6.3 Testing for Weaknesses in Geometry and Capacity

The two performance measures, delay and queue length, need to be checked at two confidence levels with RODEL. Perform a RODEL analysis at both the 50% and 85% confidence levels (CL). The 50% CL analysis represents real expectations of the modern roundabout's performance and provides for an equal comparison to other intersection types because a 50% CL is built into other software programs used to evaluate other types of intersections. The 85% CL analysis is a sensitivity check for excessive delay on any of the approaches when there are minor changes in traffic flow and capacity. A sharp rise in delay at the 85% CL on any approach leg indicates that design of that entry is approaching a high v/c ratio. A high v/c ratio indicates to the designer to re-evaluate if a modest geometric layout refinement will provide a lower v/c ratio and consequently prolong the life of the roundabout by avoiding failure of that leg.

Use engineering judgment to determine if a design resulting in an unacceptable level of service at the 85% confidence level is the best alternative at the specific location. Regardless of the level of service reported when reviewing the 85% CL, use the results from RODEL at the 50% CL when doing a comparison with other intersection alternatives.

The designer should review the residual capacity of the roundabout by using the 50% CL and increasing the flow factor (FLOF). The designer should continue to increase the flow factor until one leg or legs reach an average delay for LOS D (~ 35 seconds unsignalized control, ~ 55 seconds signalized controlled). For example, if traffic projections increase at 2 percent a year and the flow factor is increased to 1.10 before a leg or more legs reach LOS D (~ 35 seconds unsignalized control, ~ 55 seconds signalized controlled) of average delay then the roundabout would have approximately 5 years ($0.10 \div 0.02$) of residual capacity beyond its 20 year design life. This residual capacity review is a way to project/anticipate how long a roundabout will operate at acceptable LOS. The review will also indicate an overly designed roundabout by showing excessive design life which in turn could produce undesirable initial conditions such as faster entries, higher crash severity, longer pedestrian crossings, higher maintenance, etc.

20.6.4 Testing for Exclusive Lane performance and Lane by Lane Performance

At this time, we understand the new version of RODEL (RODEL 2.0) will further address lane by lane performance assessments and the analysis will no longer be conducted in the following way.

A multilane roundabout should be assessed for capacity performance of each leg. To accomplish this in RODEL the user must utilize the capacity factor (CAPF) function.

When performing a lane by lane performance assessment on a two-lane entry roundabout set the CAPF to 0.5 for each leg. Limit approximately half the traffic volume to one lane making sure to assign adequate lane volumes for the proposed lane configurations. For example, if your traffic volumes indicate 100 right turns, 500 through movements, and 400 left turns; you may consider 100 right turns and 400 through movements in one lane and 400 left turns and 100 through movements in the other lane. See [Figure 20.2](#) option 1 for example. When assessing the right turn and through movement lane insert 000 as the volume for the left turning movement and reduce the volume for the through movement by 100 to eliminate that volume from the through/right assessment and vice versa for the other lane check. Check both lanes at the 50% CL for performance. If one assessment indicates an unacceptable LOS a redistribution of traffic on each lane may be needed. Another lane configuration to try may be option 2 of [Figure 20.2](#). This may be a very iterative process in order to achieve a desired lane balance and configuration.

When performing a review of lane by lane performance assessments on a three-lane entry roundabout set the CAPF to 0.67 for two lanes or 0.33 for individual lane analysis. Check and balance the lanes similar to the dual lane example explained above. See [FDM 11-26-50](#), Section 6 for additional information on lane balance.

Exclusive right turn lanes can be configured as full bypass lanes or partial bypass lanes. See [FDM 11-26-30](#) Section 5.15 for additional information on right turn bypass lanes. Operating RODEL for exclusive right turns requires deleting the right turn volume if a full bypass lane is utilized, use 000 in the RODEL input to show this elimination of traffic. For exclusive right turn lanes that are not bypassing the roundabout entry, the volume remains in the RODEL input as part of the total approach flow only if there is no vane island or separation median. The right turns still yield but with a vane island or separation median, the right turns must be treated as a single lane entry, apart from the other approach traffic.

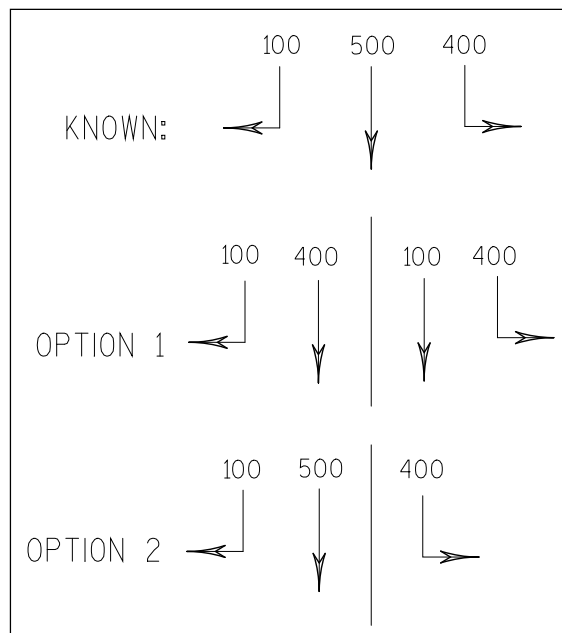


Figure 20.2. Lane by Lane Performance Example

20.6.5 Volume Diagram and Lane Configuration Sketch

Use [Attachment 20.3](#) to provide traffic volumes, existing peak hour turning volumes (AM, PM, Weekend) and design year peak hour turning volumes. Compare design year flows with existing flows and check any anomalies. It is critical that the design year flows do not exceed the capacity of the surrounding network. [Attachment 20.3](#) provides a format for a 3 or 4-leg intersection, or interchange ramp with a roundabout. Type the existing or projected peak-hour traffic volumes, by movement, in the 4 boxes at each approach and the interactive Excel spreadsheet will calculate the circulating traffic volume in the circulatory roadway adjacent to each splitter island, the exit volume and entrance volume. Circulating flow will be shown in the boxes in the center of the diagram and are used in the initial analysis of the roundabout.

The spreadsheet will also provide the correct input placement and values for RODEL. The southbound or north leg of the roundabout shall be entered as Leg 1 into RODEL. The legs shall continue to be entered into RODEL in a counter-clockwise order around the intersection. Turning flows for each leg should be entered with the first turning movement corresponding to the first exit and so on. For example, on a four legged roundabout the right turn would be the first exit, the through movement would be the second exit, the left turn the third exit and the u-turn the fourth exit.

Generally U-Turn traffic will be 1 percent of the entering traffic volume and may be much greater where there is no median opening between roundabouts. The U-turn volume shall be included in the traffic analysis.

See [FDM 11-26-020, xls1](#) (Traffic Flow Worksheet) for a working version of [Attachment 20.3](#) and store it on your computer. The numbers that are in the figure are example numbers. In the interactive mode the yellow cells are read-only. Enter turning volumes in the white cells.

A lane configuration for each entry must accompany the volume diagram to facilitate the selection of the number of lanes and the lane assignments. This is a critical step that precedes the roundabout capacity analysis and the layout process because it affects the geometry. In [Figure 20.3](#), the assessment of lane assignments for the north leg (leg 1) could include three different options.

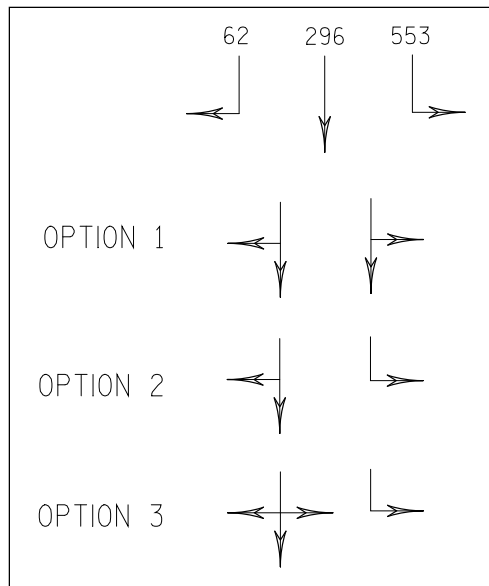


Figure 20.3. Lane Configuration Options for North Leg

Depending on the option, a spiral marking treatment to spiral out the westbound left turn may be needed. Also, the southbound exit may become one lane. Option 1 is the preferred and simplified lane configuration that works for both peak and off-peak periods. [Figure 20.4](#) is an example of the final roundabout layout.

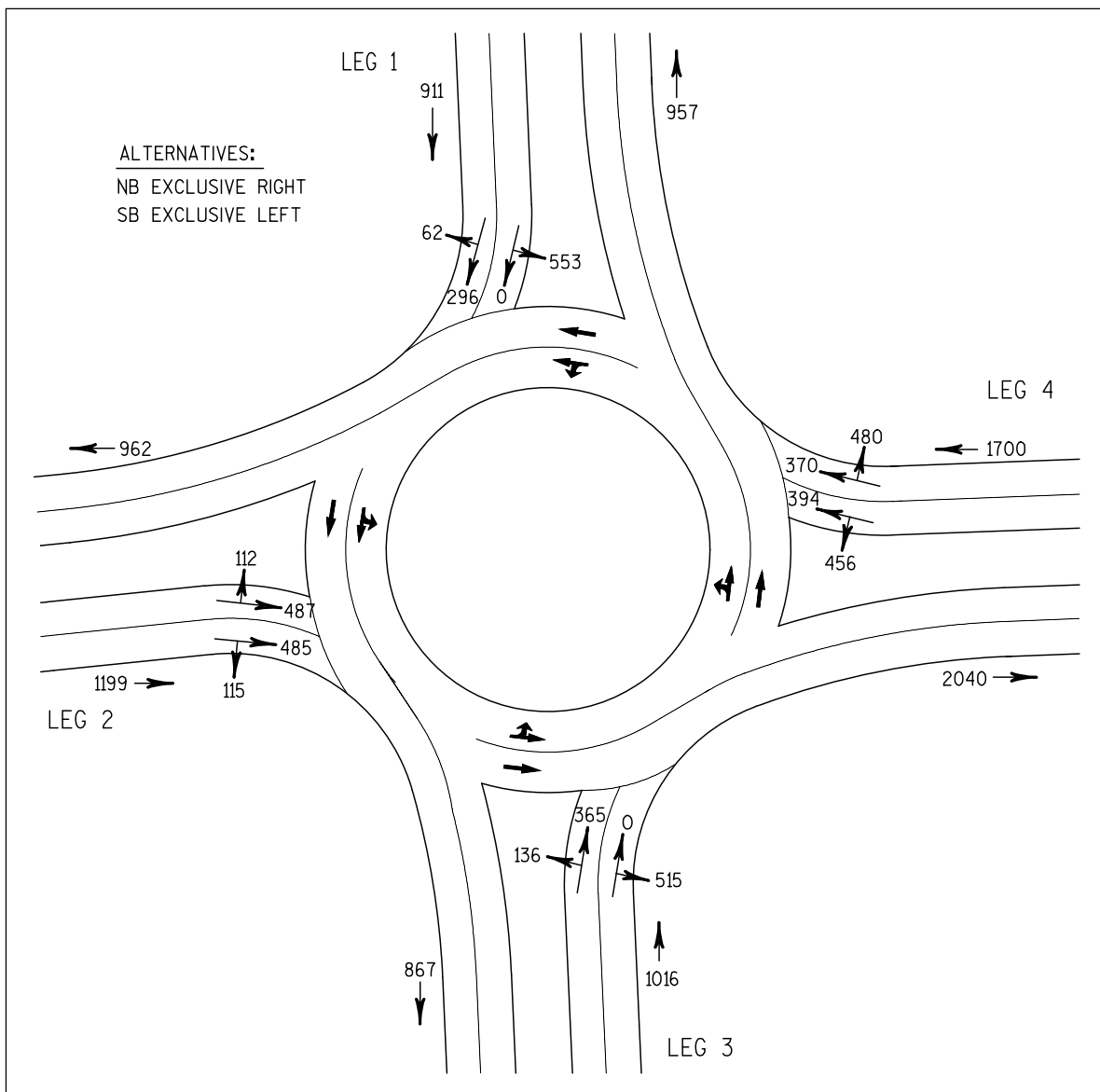


Figure 20.4. Lane Configuration Sketch

20.7 Operations and Entry Lane Pavement Markings

RODEL's capacity equations assume that there are no lane arrows on the approach lanes of roundabouts with equal traffic flow distribution between lanes. The correct use of lane arrows can be very beneficial to help approaching traffic achieve a desirable distribution of traffic between lanes. Inappropriate use of lane arrows can also reduce capacity if used incorrectly, and RODEL may therefore under estimate queues and delays in such cases.

The reduction in capacity arising from the incorrect use of lane arrows can be quite severe when a high proportion of the approach volumes use one exit. For example, assume an approach on a 4-leg roundabout has three lanes, with arrows left, straight and right. If 60% of the approach flow is straight ahead, it is constrained to the middle lane, which only has 1/3 of the approach capacity. The resulting queues can quickly expand beyond the beginning of the flare preventing access to the left and right turn lanes, further reducing capacity.

In some situations the use of appropriate lane arrows can encourage balanced lane use, thus improving capacity. Traffic often has a bias towards the right most lane. Lane arrows can either encourage this bias, or can encourage lane balance. [Figure 20.5](#) shows the alternative pavement marking. The best marking for an approach will depend on the turning volumes. The markings that produce the most balanced lane utilization are preferred. [Figure 20.5](#) (a) would be utilized with a heavy right turn and through movement. [Figure 20.5](#) (b) would be utilized with a heavy left turn and through movement.

Lane arrows can be very complex with subtle problems that can reduce capacity and cause accidents, so great

care and understanding is needed before the geometric layout is commenced.

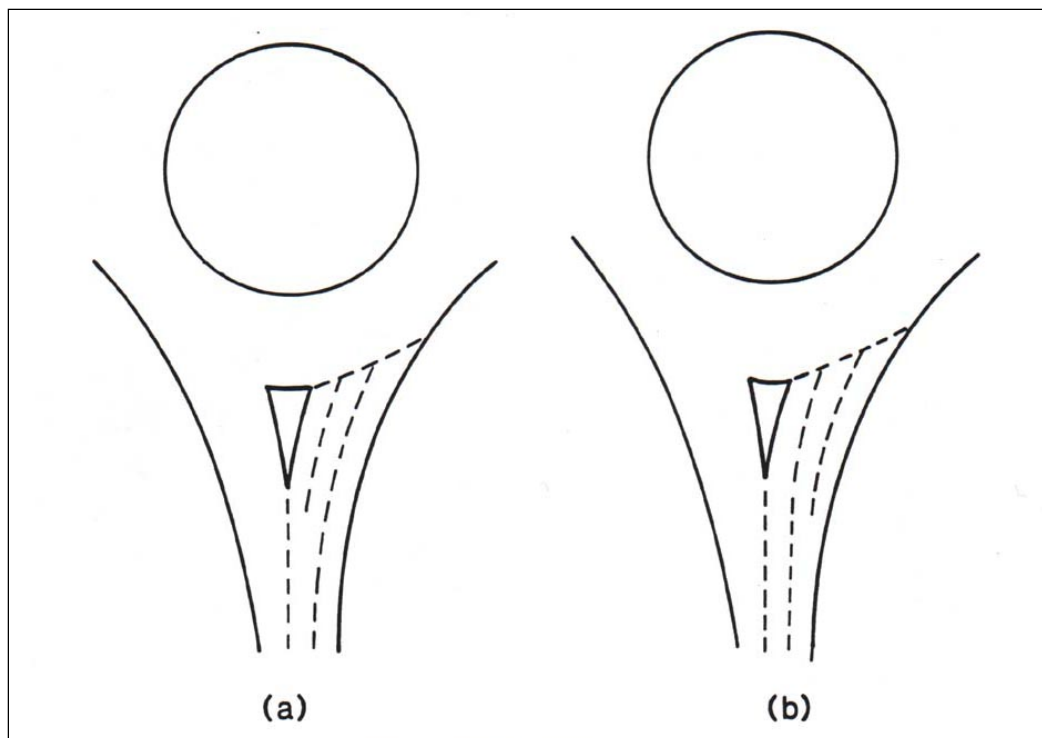


Figure 20.5. Lane Markings

20.8 Through Highway Declaration (ss 340.01(67) & 349.07)

By statutory authority a signal, roundabout or stop sign installations on a state trunk highway (STH) require an approval process. Guidance on “Through Highway Declarations” is provided in the Traffic Guidelines Manual (TGM), Section 13-1. This requirement applies to new or modified traffic control installations on a STH. Regardless of the type of traffic control proposed, associated “through highway declarations” need to be developed and are maintained by the Regional Traffic staff.

20.9 Speed Zone Declarations (ss 346.57 & 349.11)

Also by statutory authority speed zone declarations are required when the traffic on a STH is required to reduce speed as a result of a regulatory speed sign installation. Guidance on “Speed Limits” is provided in the TGM, Section 13-5. If speed reductions are required in advance of an intersection traffic control device, develop a declaration based on an engineering study coordinated with Region Traffic staff.

20.10 References

- [1] Roundabouts: An Informational Guide, Publication No. FHWA-RD-00-067, June 2000
<http://www.tfhrc.gov/safety/00068.htm>
- [2] Status Report: Roundabouts, Vol. 35, No. 5, Insurance Institute for Highway Safety, May 13, 2000
<http://www.iihs.org/sr/pdfs/sr3505.pdf>
- [3] Traffic Queues and Delays at Road Junctions, TRRL Report LR 909, 1979. Kimber, RM and Hollis EM
- [4] The Traffic Capacity of Roundabouts TRRL Report LR 942, 1980. Kimber, RM
- [5] Gap-Acceptance and Empiricism in Capacity Prediction, TRRL Kimber RM
- [6] Accidents At 4-Arm Roundabouts, TRRL Report LR 1120, 1984. Maycock, G and Hall, RD

LIST OF ATTACHMENTS

[Attachment 20.1](#) Key Roundabout Design Parameters

[Attachment 20.2](#)

Geometric Design Parameters

[Attachment 20.3](#)

Traffic Flow Worksheet

FDM 11-26-25 System Considerations[February 25, 2011](#)**25.1 System Considerations**

Roundabouts may need to fit into a network of intersections with the traffic control functions of a roundabout supporting the function of nearby intersections and vice versa. Because the design of each roundabout generally follows the principles of isolated roundabout design, this guidance is at a conceptual and operational level and generally complements the planning of isolated roundabouts. In many cases, site-specific issues will determine the appropriate roundabout design elements.

Roundabout corridors containing multiple roundabouts may be analyzed with proper knowledge and extreme care in calibrating the system to comply with RODEL output. Software that is used to model a corridor uses the gap method of analysis and RODEL uses the British empirical method of analysis. Therefore, only those that understand these differences and know how to calibrate volumes appropriately should model a roundabout corridor. Even with calibration the simulation modeling may not be truly accurate but may provide information when comparing the magnitude of differences between alternatives. Simulation programs at this time use the gap method of analysis and therefore tend to show more congestion at the approach to a roundabout than the British Empirical Method when the v/c ratio is high.

25.2 Adjacent Intersections and Highway Segments and Coordinated Signal Systems

A comprehensive traffic analysis is needed to determine how appropriate it is to locate a roundabout within a coordinated signal network. There may be situations where an intersection within the coordinated signal system requires a very long cycle which is caused by high side road traffic or large percentage of turning movements and is dictating operations and reducing the overall efficiency for the coordinated system. Replacing a signalized intersection with a roundabout may allow for the system to be split into two systems thus improving the efficiency of both halves while also improving the efficiency of the entire roadway segment. A traffic analysis is needed to evaluate each specific location.

It is generally undesirable to have a roundabout located near a signalized intersection; however, a corridor analysis may show the roundabout as a good option. Traffic queues that extend into adjacent intersections need to be analyzed further.

Prohibit on-street parking within 75 feet of the yield point or further depending on site-specific conditions. Also, avoid parking near the roundabout exit. Factors that influence the decision to prohibit on-street parking near a roundabout may include: Adjacent access, location of pedestrian crossing, and approach or departing curvature. Generally, it is not desirable to allow parking on either side of the roadway within the splitter island area or in the transition to the splitter island.

25.3 Roundabouts in an Arterial Network

In order to understand how roundabouts operate within a roadway system, it is important to understand their fundamental arrival and departure characteristics and how they may interact with other intersections and highway features.

25.3.1 Planned Network, Access Management

Rather than thinking of roundabouts as an isolated intersection or replacement for signalization, identify likely network improvements early in the planning process. This is consistent with encouraging public and other stakeholder interaction to prepare or update local comprehensive or corridor plans with circulation elements. Project planning and design are likely to be more successful when they are part of a larger local planning process. Then, land-use and transportation relationships can be identified and future decisions related to both.

Roundabouts may be integral elements in village, town, and city circulation plans with multiple objectives of improving circulation, safety, pedestrian and bicycle mobility, and access management. Roundabouts rely on the slowing of vehicles to process traffic efficiently and safely which results in a secondary feature of “calming” traffic. It can be expected that local studies and plans will be a source of requests for roundabout studies, projects, and coordination on state arterials. A potential use of arterial roundabouts is to function as gateways or entries to denser development, such as villages or towns, to indicate to drivers the need to reduce speed for upcoming conflicts including turning movements and pedestrian crossings.

Retrofit of suburban commercial strip development to accomplish access management objectives of minimizing conflicts can be a particularly good application for roundabouts. Raised medians are often designed for state arterials to minimize left turn conflicts; and roundabouts accommodate U-turns, where U-turn at signals in

Wisconsin is illegal. Left-turn exits from driveways onto an arterial that may currently experience long delays and require two-stage left-turn movements could be replaced with a simpler right turn, followed by a U-turn at the next roundabout. Again, a package of improvements with driveway consolidation, reverse frontage, and interconnected parking lots, should be planned and designed with close local collaboration. Also, a roundabout can provide easy access to corner properties from all directions.

25.3.2 Platooned Arrivals on Approaches

Vehicles exiting a signalized intersection tend to be grouped into platoons. Platoons, however, tend to disperse as they move down-stream. Roundabout performance is affected by its proximity to signalized intersections and the resulting distribution of entering traffic. If a signalized intersection is very close to the roundabout, it causes vehicles to arrive at the roundabout in closely spaced platoons. The volume of the arriving platoon and the capacity of the roundabout will dictate the ability of the roundabout to process the platoon. Analyze these situations carefully to achieve a proper design for the situation. Discuss proposed roundabout locations with the Regional traffic section staff.

25.3.3 Roundabout Departure Pattern

Traffic leaving a roundabout tends to be more random than for other types of intersection control. Downstream gaps are shorter but more frequent as compared to a signal. The slower approach and departing speeds along with the gaps allow for ingress/egress from nearby driveways or side streets. The slowing effects are diminished as vehicles proceed further downstream. However the gaps created at the roundabout are carried downstream and vehicles tend to disperse again providing opportunities for side street traffic to enter the main line roadway.

Sometimes traffic on a side street can find it difficult to enter a main street at an un-signalized intersection. This happens when the side street is located between two signalized intersections and traffic platoons from the signalized intersections arrive at the side street intersection at approximately the same time. If a roundabout replaced one of these signalized intersections, then its traffic platoons would be dispersed and it may be easier for traffic on the side street to enter the main street. Alternatively, when signals are well coordinated they may provide gaps at nearby intersections and mid-block for opportunities to access the main line.

If a roundabout is used in a network of coordinated signalized intersections, then it may be difficult to maintain the closely packed platoons required. If a tightly packed platoon approached a roundabout, it could proceed through the roundabout as long as there was no circulating traffic or traffic upstream from the left. Only one circulating vehicle would result in the platoon breaking down. Hence, this hybrid use of roundabouts in a coordinated signalized network needs to be evaluated carefully.

Another circumstance in which a roundabout may be advantageous is as an alternative to signal control at a critical signalized intersection within a coordinated network. Such intersections are the bottlenecks and usually determine the required cycle length, or are placed at a signal system boundary to operate in isolated actuated mode to minimize their effect on the rest of the surrounding system. If a roundabout can be designed to operate within its capacity, it may allow a lowering of the system cycle length with resultant benefits to delays and queues at other intersections.

25.4 Closely Spaced Roundabouts

It is sometimes desirable to consider the operation of two or more roundabouts in close proximity to each other. In these cases, the expected queue length at each roundabout becomes important. Compute the expected queues for each approach to check that sufficient queuing space is provided for vehicles between the roundabouts. If there is insufficient space, then drivers may occasionally queue into the upstream roundabout and may cause it to reduce the desired operations. However, the roundabout pair can be designed to minimize queuing between the roundabouts by limiting the capacity of the inbound approaches.

Closely spaced roundabouts may improve safety and accessibility to business or residential access or side streets by slowing the traffic on the major road. Drivers may be reluctant to accelerate to the expected speed on the arterial if they are also required to slow again for the next close roundabout. This may benefit nearby residents. Additional information including closely spaced offset T-intersections is contained in FHWA's: Roundabout guide.

25.5 Roundabout Interchange Ramp Terminals

Freeway ramp junctions with arterial roads are potential candidates for roundabout intersection treatment. This is especially so if the subject interchange typically has a high proportion of left-turn flows from the off-ramps and to the on-ramps during certain peak periods, combined with limited queue storage space on the bridge crossing, off-ramps, or arterial approaches. In such circumstances, roundabouts operating within their capacity are particularly amenable to solving these problems when compared with other forms of intersection control. OSOW vehicle accommodations need to be evaluated when considering a roundabout ramp terminal at the junction of

two OSOW Freight Network routes. Evaluate the entry widths, truck apron width, possible bypass lanes or connections, and additional right-of-way that may be needed to allow OSOW vehicles to navigate from one OSOW route to another.

Occasionally, an OSOW vehicle may have to bypass a bridge by taking the off ramp and making a through movement and entering the on ramp. Design the median island to accommodate the OSOW through movement. Refer to [FDM 11-30-1](#) for additional guidance on interchange design.

Traffic performance evaluation of the roundabout interchange is the same as for a single conventional roundabout. The maximum entry capacity depends on the circulatory flow and the geometry of the roundabouts. The evaluation process is included in [FDM 11-25-3](#).

The benefits and costs associated with this type of interchange also follow those for a single roundabout. Some potential benefits of roundabout interchanges are:

- The queue length on the off-ramps may be less than at a signalized intersection. In almost all cases, if the roundabout would operate below capacity, the performance of the on-ramp is likely to be better than if the interchange is signalized.
- The intersection site distance is much less than what it is for other intersection treatments.
- The headway between vehicles leaving the roundabout along the on-ramp is more random than when signalized intersections are used. This more random ramp traffic allows for smoother merging behavior onto the freeway and a slightly higher performance at the freeway merge area similar to ramp metering.

There are no special design parameters for roundabout interchanges. They are only constrained by the physical space available to the designer and the configuration selected. The raindrop form, which does not allow for full circulation around the center island, can be useful if grades are a design issue since they remove a potential cross-slope constraint on the missing circulatory road segments. If there are more roads intersecting with the interchange than the single cross road, then two independent circular roundabouts are likely to be the best solution.

Refer to the FHWA Roundabout Guide, Chapter 6, all of Sections 6.2 and 6.3. for additional information.

25.6 Traffic Signals at Roundabouts

Roundabouts typically are not planned to include metering or signalization.

The “pedestrian hybrid signal” sometimes referred to as the HAWK crosswalk signal is discussed in [FDM 11-26-10](#), Section 1.1.

25.7 At-Grade Rail Crossings

Locating any intersection near an at-grade railroad crossing is generally discouraged. However, due to necessity, intersections are sometimes located near railroad-highway at-grade crossings. When considering locating a roundabout near a railroad, contact the Region Railroad Coordinator early in the process. It is preferable to cross one of the legs of a roundabout and leaving a desired distance of at least 100 feet from the center of the track to yield line at the entrance to the roundabout. Consider allowing the railroad track to pass directly through the circle center of the roundabout rather than through another portion of the circular roadway if the at-grade crossing is not on one of the legs. Also, consider the design year traffic on the roadway and the rail number of daily trips, speed of train, and length of train when evaluating the intersection control needed in close proximity to the railroad.

There are a few documents available besides [FDM 11-60-1](#) for additional information on roundabouts in the vicinity of at-grade rail crossings.

1. WisDOT Transportation Synthesis Report, US search, which includes a link to the FHWA Roundabout Guide. <http://www.dot.wisconsin.gov/library/research/docs/tsrs/tsrroundaboutsrail.pdf>
2. WisDOT Transportation Synthesis Report, International search. Technical Guide “Railroad Crossing Safety In the Proximity to Roundabouts” <http://www.dot.wisconsin.gov/library/research/docs/tsrs/tsrroundaboutsrail-europe.pdf>). This document has 3 parts. It starts by (1) showing the WisDOT synthesis of the international search results, (2) French Guide about rail crossings in the French language, (3) The French Guide translated into English.
3. A national listing of roundabouts in close proximity to a railroad crossing: [FDM 11-26-25, doc1](#)

30.1 Introduction

In a general sense, roadway engineering is often an iterative process. Roundabout design, due to the dynamic balancing of considerations and the often-profound effect that manipulation of geometric elements can have on performance, tends to be iterative by its nature, sometimes requiring numerous iterations to achieve the desired balance between geometric, operational and safety factors. Similarly, even though a step-by-step design process is presented in this section, the designer must understand that adherence to design principles, awareness, and understanding of the inherent design tradeoffs are the central points of design regardless of whether any design procedure is followed.

The foreword of the FHWA publication *Roundabouts: An Informational Guide* states that: "Roundabout operation and safety performance are particularly sensitive to geometric design elements. Uncertainty regarding evaluation procedures can result in over-design and less safety. The 'design problem' is essentially one of determining a design that will accommodate the traffic demand while minimizing some combination of delay, crashes, and cost to all users, including motor vehicles, pedestrians, and bicyclists. Evaluation procedures are suggested, or information is provided, to quantify cost and how well a design achieves each of these aims."

"Since there is absolutely no optimum design, this guide is not intended as an inflexible 'rule book,' but rather attempts to explain some principles of good design and indicate potential tradeoffs. In this respect, the 'design space' consists of performance evaluation models and design principles such as those provided in this guide, combined with the expert heuristic knowledge of a design. Adherence to these principles still does not ensure good design, which remains the responsibility of the designer."

More so than conventional intersections or practically any other design form, the geometric design of roundabout intersections directly dictates their capacity and operational performance. This is so much the case that the geometric and operational analysis, generally considered distinct disciplinary pieces of project design and often performed separately on typical projects, are inseparable in roundabout design. For that reason, much of the content in this section invokes traffic engineering terms and subject matter that centers on achieving operational goals while balancing them with safety and other considerations.

In analysis of roundabout capacity and delay, WisDOT recognizes the British Empirical Method as being successful in modeling real-world conditions for roundabout operation and prescribes its use in design of roundabouts. This section presents a process methodology based on the British Empirical Method and the compatible RODEL computer software.

30.2 Roundabout Design Process

As discussed previously, the general nature of the roundabout design process is an iterative one. It is also a process in which minor adjustments in geometric attributes can have significant effects on the performance of the design. In the execution of this process, there must be an awareness of this iterative nature as well as an understanding that any of the steps may need to be looped back to an earlier step for adjustment.

Because of this iterative process as well as the fact that the optimal position of the roundabout may not be finally determined until geometrics can be roughly investigated for various location options, it is typically advisable to prepare initial layout drawings with a hand-sketch methodology and level of detail. This method allows rough investigation of feasibility and compatibility of individual components before significant effort is invested in detailing design elements. Furthermore, it is often a benefit to the public involvement process to initially exhibit hand sketches rather than finished-looking engineering drawings; this can avoid the appearance that the design has already been determined.

There are no easy ten-steps to roundabout design. Much of the knowledge in roundabout design is counter-intuitive to the technically minded engineer. Designing roundabouts can range from easy (single lane roundabouts) to very complex (multi-lane roundabouts). Essentially, roundabout design is as far away from a "cookie cutter" design as intersection design can get.

Although it may appear inherently otherwise and extensively attempted, roundabouts are not homogeneous and cannot be standardized. There are many different types of roundabouts, such as single lanes, two-lanes, three-lanes, circles, ellipses, bypass lanes, "snagged" bypass lanes, double roundabouts, spirals, etc, in which a number of combinations or multiple combinations of the above can be in one roundabout. Each roundabout is unique where each potential "type" of roundabout is applied in different situations in which site-specific problems require special and distinctive solutions. The major differences in design techniques and skill levels fall between single lane roundabouts and multi-lane roundabouts where different principles apply.

Roundabout design is fundamentally holistic. The whole is more important than the parts. In other words, how the intersection functions as a single traffic control device is more important than the actual values of the

specific design components (e.g. a radius). However, how the parts interact with each other is crucially important. Likewise, although individual geometric values are not as important as the intersection operation as whole, the values must be within ranges that generally succeed. [Figure 30.1](#) provides an example of a holistic flow chart that guides a designer through the entire Roundabout Design Process.

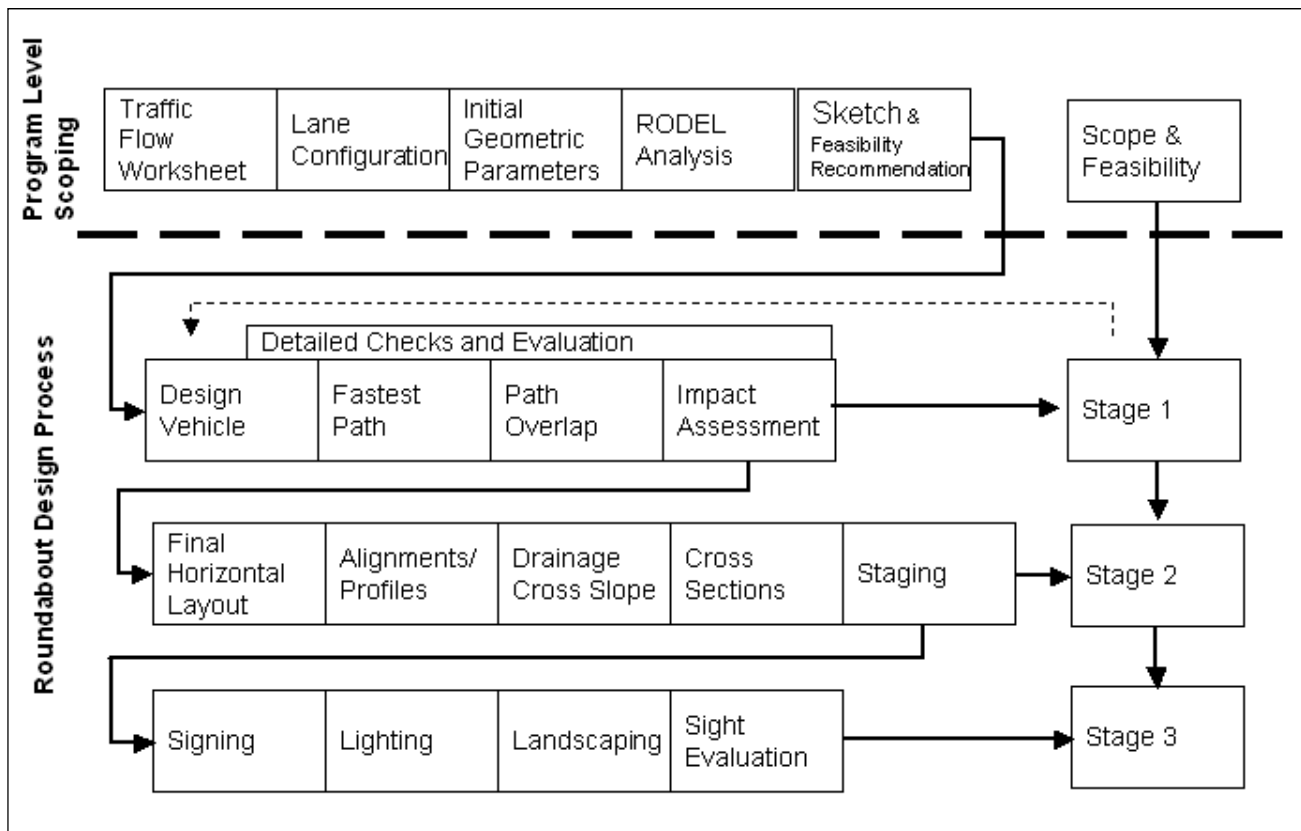


Figure 30.1. Roundabout Evaluation & Design Process

30.3 General Design Steps & Explanation

The following general design steps will typically apply to most roundabout design practices. However, each roundabout requires a different design and thinking process depending on the unique design constraints, traffic volumes, roadway speeds, existing topography, and geometric alignments of the roadways. Not all aspects of design or the design process are included herein, however, the provided general design steps should be sufficient to get most designers started in an initial conceptual roundabout design.

Step 1 - Review of Existing Conditions

Review the most recent site plans and roadway alignment information in an electronic format (e.g. CAD-based software). Review existing roadways with respect to surrounding topography, centerlines, curb faces, edge of pavement, roadway lane markings, existing or proposed bike lanes, nearby crosswalks, environmental constraints, buildings, drainage structures, adjacent access points, multi-use paths, rail crossings, school zones, and right of way constraints. This should include any special design constraints such as specific properties that cannot be encroached or specific desired lane widths. Review any traffic study, which should include final future design year traffic volumes and assumptions of the proposed intersection or corridor project.

These items should provide adequate background traffic conditions, existing traffic conditions within and outside the project area, as well as the level of detail, design parameters, right of way constraints, and location for the proposed roundabout.

Step 2 - Review Future Conditions

The future traffic conditions with respect to the operations and flows of the existing roadways should be reviewed and possibly discussed with the lead jurisdiction for project understanding and operational issues. These operational issues including the potential excessive delays should be utilized in the design process and geometric criteria. In addition, any relevant adjacent site plans, access points, restricted historical or wetland areas, and roadway cross-sections that may affect the roundabout design should be provided, reviewed, and

incorporated.

Review the future AM, PM and OP (and midday in tourist areas) peak hour turning movement volumes at the intersection developed from the design year projected traffic volume data. Use the Traffic Flow Worksheet in [FDM 11-26-20](#) and a simple schematic diagram consisting of the final future peak hour turning movement volumes at the intersection(s). In order to accurately identify the roundabout geometric and capacity needs, the following should be provided and required prior to starting the capacity (RODEL) analysis or roundabout design:

- Future AM Peak Hour Turning Movement Volumes
- Future PM Peak Hour Turning Movement Volumes
- Future Percent Heavy Vehicles (by Approach) for Each Peak Hour
- Design Vehicle Type by Turning Movement (i.e. WB-50, WB-65, or special design vehicle)
- Vertical Constraints
- ROW Constraints
- Existing and Proposed Roadway Alignment Base Map (with travel lanes, proposed face of curb tie-in, striping, bike lanes, ROW, etc.)
- Pedestrian Volumes (if significantly high),
- Identify if Bike Lanes and Sidewalks will be Needed / Proposed

Step 3 - Understand the Specific Design Problem(s)

Prior to commencing a design, the designer must first understand the design problem(s) to be solved (ROW issues, acute angles, grades, approach legs, roadway alignment, etc.) with the specific site location. After evaluating the traffic volumes, the designer should have an understanding of how many lanes may be initially required such as a heavy north south through movement may require two-lane entries and exits northbound and southbound.

A general roundabout diameter can then be chosen based on the traffic needs, proximity to constraints, design vehicle, and the relative speeds of the roadways (i.e. if high speed approaches present). The designer must be conscious of the design vehicle when choosing a diameter. Refer to [FDM 11-25 Table 3.1](#) as a first step in the evaluation process if you have no other values.

Step 4 - Perform Capacity Analysis

After obtaining all of the pertinent information regarding the roadways, site, and traffic volumes, and a general roundabout diameter has been initially identified, the designer should perform a geometric analysis of the proposed roundabout using the roundabout design software RODEL. Refer to [FDM 11-26 Figure 20.5](#) Traffic Flow Worksheet to assist with inputting the RODEL volume data. The RODEL output will assist in developing the initial lane geometry and capacity requirements for the roundabout based on the future design volumes.

This will set the design requirements for the conceptual roundabout design. The AM and PM, and sometimes a weekend peak, traffic volumes will need to be analyzed at the intersection at both the standard 50 and peak 85 percentile confidence levels for a minimum of four RODEL model calculations. This will provide that the roundabout will operate appropriately under all peak hour traffic conditions during typical design and critical design operations. The final results of this analysis will produce key information to include in the roundabout design, some of which are the following initial information:

- Initial roundabout diameter (estimated size)
- Entry lane configurations at each approach
- Future traffic volume capacity by approach
- Minimum approach widths and entry radii of the roundabout
- Delay of each approach and the overall delay of the intersection
- Queue lengths for each approach
- Future level of service

Step 5 - Lane Configuration and Roundabout Placement

Once the minimum design requirements have been established, a modern roundabout design can be sketched by initially identifying the flow of traffic, lane configuration, and approach lane assignment requirements, the circulatory roadway width and the exits of the roundabout. This task includes the placement of the roundabout's circle to roughly determine the lane configuration and location of the proposed roundabout. Special consideration should be taken for any skewed intersection angles and ROW constraints.

Step 6 - Plan Initial Layout

Once the capacity requirements have been identified, the hand sketch or initial conceptual layout should be refined (prior to CAD). A preliminary geometric layout should be developed only to further identify the site's specific design issues. Once the designer has a grasp of these issues, the concept should be refined iteratively to develop a solid sketch (without the use of exact values such as radii). Visual inspection of the sketch concept can then further identify fastest path, ROW, deflection, leg angles, and other issues.

The purpose of this process is simply because designers, who first design in CAD, find it difficult to completely move or change a roundabout design with the level of effort already completed. Their minds become narrow and focused on the details of the exact geometry opposed to a holistic roundabout design.

Step 7 - Formalize Design Digitally (CAD)

Once the general location and roundabout configuration has been preliminarily developed and all of the design issues have been resolved, a full conceptual modern roundabout design can be initiated in CAD. Assuming all of the above information has been completed and thoroughly reviewed the designer can develop a horizontal roundabout design for the intersection with respect to the required geometric parameters as well as safety in an electronic CAD file format. The designer should complete a roundabout design with respect to the face of curb for the intersection. In multi-lane designs, the lane striping is just as critical as the face of curb to minimize entry and exit path overlap, provide proper lane widths and widening, as well as communicate the lane markings and possible spiral lane movements.

It is critically important that the horizontal geometry of the roundabout adhere to the required safety and capacity parameters in the roundabout design. The design must utilize the RODEL output (see [FDM 11-26-20](#) for typical capacity ranges) with appropriate design use and application of the six basic geometric roundabout parameters (E, L', V, Phi, R, and D). The entry width (E), average effective flare length (L'), entry angle (phi), the entry radius (R1), and the inscribed circular diameter (ICD) all directly relate to the capacity and safety of modern roundabouts. All of these values should not be understated or overemphasized as they all directly relate to each other. The proper balance and design use of these six geometric parameters can result in an efficient and safe design.

Step 8 - Design Vehicle Check & Modifications

Review the specific design vehicle for each turning movement is adequate within the roundabout design. A CAD-based software program such as AutoTurn or AutoTrack should be used for the turning movements of the intersection roadways to verify proper truck turning radii through the roundabout for every approach and movement. In addition, the truck apron minimum width is 12-feet and may be wider in some situations to better accommodate OSOW vehicles. Refer to [FDM 11-26-50](#) for assistance in sizing the truck apron. The information provided in [FDM 11-26 Figure 50.1](#) is for guidance only and not a standard sizing chart. All truck movements should have a buffer space between the swept path of trucks and the face of curb equal to 2 feet. Contact the Regional Freight Operations Unit for the OSOW vehicle inventory to help in the design process for turning and/or through movements.

Step 9 - Safety and Fastest Path Review

Fastest path design speeds as well as a number of other safety factors and design features such as the phi angle must be performed and checked. The specific fastest path design should be developed and reviewed as adequate and reasonable (speeds and deflection). If deficiencies or deviations in any of the design features and safety factors are found, the roundabout must be reanalyzed and redesigned either with many small changes or by completely shifting alignments and geometry or the placement of the circle with an entire redesign effort (iterative process).

Step 10 - Accessorize the Design

When a preliminary design with respect to the face of curb (and striping for multi-lane roundabouts) has been completed that functions for the design vehicle(s), additional amenities should be completed at this stage of design. The design should contain amenities such as crosswalks, detached sidewalks, bike paths and ramps, truck aprons, ADA ramps, and the like. All efforts should be made to avoid any ROW issues. The design must be based upon acceptable thresholds to maintain adequate speeds and safety design elements.

At this stage (Stage 1) of the design process, some form of approval or review consultation may be performed by a qualified designer. Once a roundabout design has been properly designed with respect to horizontal geometry, there are many other geometric and non-geometric design components that must now be completed in order for a roundabout to function as it was designed. These design components are key to the public driving the roundabout as it was intended without further safety or operational issues. These items are identified in Stage 1, 2, and 3.

Stage 2 and 3 aspects of roundabout design including horizontal geometry, vertical profiles, signing, pavement

marking, landscaping, lighting, and construction materials should either be designed by or reviewed by an qualified roundabout designer. Nothing can replace real-world design and field experience.

Continual practice, mentoring from roundabout experts, roundabout training and education, and quality roundabout review greatly assists the designer in understanding all aspects of the design of modern roundabouts. However, all designers must spend time in the field reviewing roundabout construction and completed roundabouts in order to understand roundabouts and roundabout design completely. After years of daily practice, one can still learn. Small changes in roundabout design (in the order of inches) can make or break the operation and safety of a modern roundabout.

30.4 Design Principles

The overall guiding principle in the design of a roundabout is a provision of an operationally adequate facility that also provides good safety performance. In roundabout geometric design, these are often competing goals, as geometric elements that promote higher traffic flows often allow higher speeds into and through the roundabout. Issues relating to overall speed and speed consistency, between different traffic streams or between successive elements within a traffic stream, are the most prevalent cause of safety problems. The balancing of the speed/capacity/safety relationship is the most important principle in roundabout design.

The process of designing roundabouts may require a considerable amount of iteration among geometric design, operational analysis, and safety evaluation. Minor adjustments in geometry can result in significant changes in safety and/or operational performance. Thus, the designer often needs to revise and refine the initial design to enhance the roundabouts capacity and safety. It is not typically possible to produce an optimal geometric design on the first attempt.

Because roundabout design is an iterative process, it may be advisable to prepare the initial concept drawings at a sketch level detail. It is important that the individual components are compatible with each other so that the roundabout will meet its overall performance objectives. Before the details of the geometry are finalized, three fundamental elements must be determined in the Scoping and Feasibility stage.

1. The optimal size
2. The optimal position
3. The optimal alignment and arrangement of the approach legs

Following is a list of other important factors that are incorporated into the roundabout design.

1. Fastest speed path - The fastest speed path is a basic principle of roundabout design to restrict operating speed by deflecting the paths of entering and circulating vehicles. Refer to the FHWA Roundabout Guide, Chapter 6 and Exhibit 6-12, for additional information on vehicle path curvature.
2. Circulatory roadway width - The width between the outer edge of the inscribed diameter at the curb face of this roadway and the central island curb face. It is typically 1.0 to 1.2 times the width of the widest entry width. It does not include the width of any traversable apron, which is defined to be part of the central island. The circulatory roadway width defines the roadway width, curb face to curb face, for vehicle circulation around the central island.
3. Exit radius - The radius of curvature of the outside curb face at the exit.
4. Exit width - The exit width defines the width of the exit where it meets the inscribed circle. It is measured perpendicularly from the right curb face edge of the exit to the intersection point of the left curb face edge and the inscribed circle.

30.4.1 Designing With Trade-offs In Mind

The selection and arrangement of geometric design elements and their relationships to one another is referred to as design composition. When composing a design the tradeoffs of safety, capacity and cost must be recognized and assessed throughout the design process. The effects of adding to one component of design impact another. [Table 30.1](#) below identifies the trade-offs of adding to one element at the expense of another.

Table 30.1 Effects of Design Elements on Safety and Operations

Element	Safety	Capacity
Wider entry	Less safe	Increase
Wider Circulatory roadway	Less safe	Better
Larger entry radius	Less safe	Better
Larger inscriber circle diameter	Less safe	Better
Larger angle between entries	Safer	Decrease
Smaller entry angle (phi)	Poorer sight	Better
Longer flare length	Neutral	Better

30.5 Geometric Design

Refer to Chapter 6 of the FHWA Roundabout Guide for the fundamental design principles as guidance. This document provides guidelines for each geometric element. Further guidelines specific to two-lane entry are provided in the latter part of Chapter 6. Note that two-lane entry roundabout design is significantly more challenging than one-lane entry roundabout design. Many of the techniques used in one-lane entry roundabout design do not directly transfer to multi-lane design. This procedure provides recommended changes to FHWA Roundabout Guide, Chapter 6. Therefore, designers must become very familiar with Chapter 6 in the FHWA Roundabout Guide and the changes herein.

Below are design guidelines that apply to WisDOT design that differ from the FHWA Roundabout Guide by section.

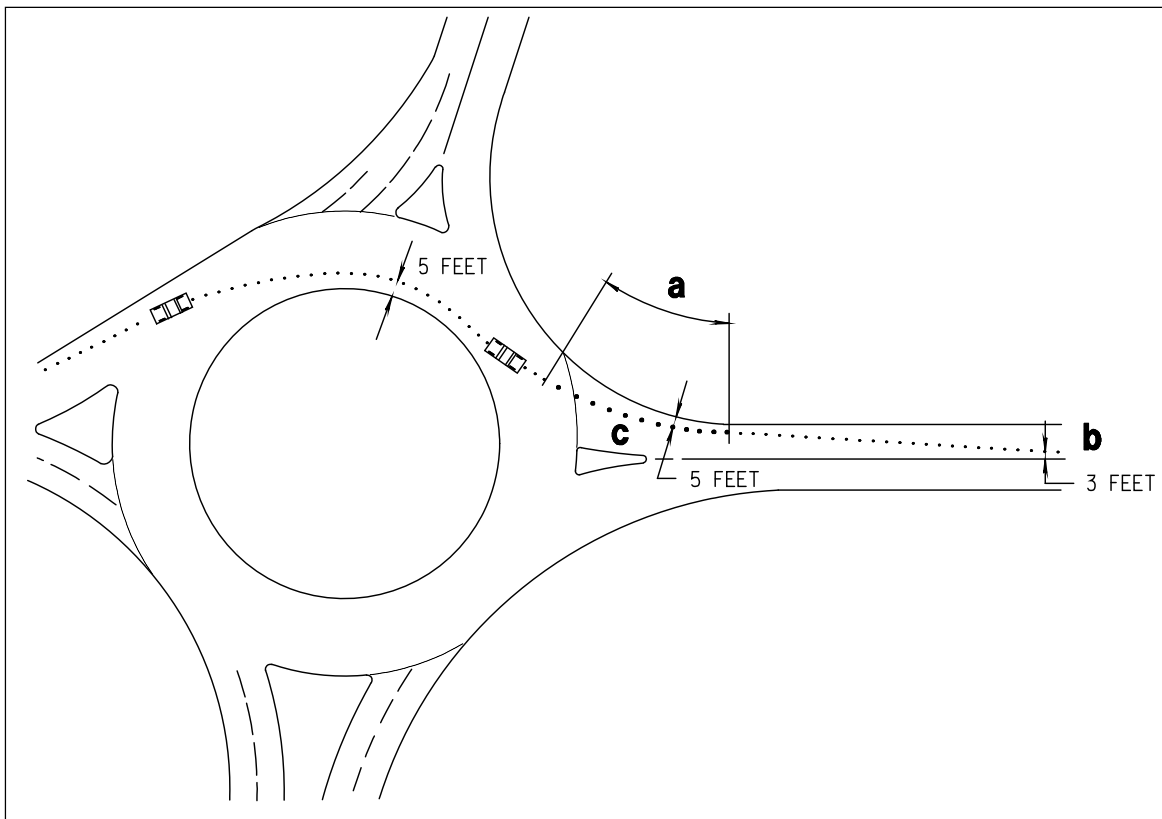
30.5.1 FHWA Section 6.2.1.2, Design speed

WisDOT is designing for the urban single lane, urban multi-lane, rural single lane, and the rural multi-lane. At this time WisDOT is not evaluating the mini-roundabout or the urban compact.

30.5.2 FHWA Section 6.2.1.3, Vehicle Paths

Determine the smoothest, fastest path (spline curve) possible for a single vehicle, in the absence of other traffic and ignoring all lane line markings, traversing through the entry, around the central island, and out the exit. Usually the critical fastest path is the through movement, but in some situations it may be a right turn movement.

Fastest speed path is a critical element in the design of roundabouts. Use the FHWA Roundabout Guide, Exhibit 6-5 and Exhibit 6-7 for single lane and rather simple multi-lane design with low pedestrian activity. Use Exhibit 6-5 to determine the radii values for R1, R2 and R3 fastest speed path. Use Exhibit 6-7 to determine the radius value for R5 fastest speed path. Do not use Exhibit 6-6 because the lane lines (the white dashed lines that separate traffic going in the same direction) shall be ignored on multi-lane roundabouts for fastest speed analysis. The R4 value for the roundabout design does not control the fastest speed path but may be checked to determine speed consistency. The vehicle path offset of 5 feet as shown in Exhibit 6-5 and 6-7 are measured from the concrete curb face (not the flange line). In the situation where the approach to the roundabout has centerline pavement marking on the left side and no curb face then offset 3 feet from the centerline pavement marking. [Figure 30.2](#) shows how to measure entry path curvature for R1. The entry path curvature is measured on a curved path near the yield point over which the tightest radius occurs. A step by step process for creating a Microstation or AutoCAD spline curve is provided in [FDM 11-26-50](#).



a - The radius should be measured over a distance of 65 to 80 feet. It is the minimum that occurs along the approach entry path near the yield point but not more than 165 feet in advance of it.

b - Beginning point is 3 feet from a pavement marking with no curb face present and is 5 feet from the left curb face (if raised curb median) at a point not less than 165 feet from the yield point. This point is a continuation of a vehicle path, not a point with deflection.

c - Vehicle entry path curvature.

Figure 30.2. Determination of Entry Path Curvature

The radii described in [Table 30.3](#) are used to define the fastest path through a roundabout. They are illustrated in Exhibit 6-12 of the FHWA Roundabout Guide.

Table 30.3 Roundabout Radii

Radius	Description
Entry Path Radius, R1	The minimum radius on the fastest through path prior to the yield line. This is not the same as Entry Radius.
Circulating Path Radius, R2	The minimum radius on the fastest through path around the central island.
Exit Path Radius, R3	The minimum radius on the fastest through path into the exit.
Left Turn Path Radius, R4	The minimum radius on the path of the conflicting left-turn movement.
Right Turn Path Radius, R5	The minimum radius on the fastest path of a right-turning vehicle.

30.5.3 FHWA Section 6.2.1.5, Speed Consistency

In addition to achieving the appropriate design speed for the fastest movements, the relative speeds between consecutive geometric elements should be minimized and the relative speeds between conflicting traffic streams should be minimized. Ideally, the relative differences between all speeds within the roundabout will be no more

than 6 mph. However, it is often difficult to achieve this goal, particularly at roundabouts that must accommodate large trucks. In these cases, the maximum speed differential between movements shall be no more than 12 mph. Typically the R2 values for radius and speed are lower than the R1 values on single-lane entries. However, this is seldom achievable with multi-lane entries. With either single- or multi-lane entries, R2 values should be lower than the R3 values.

The maximum R1 radius is 250 ft. Generally for urban roundabouts with pedestrian accommodations a lower speed entry is desirable. A typical R1 may range between 150 and 230 feet. Rural roundabouts typically allow slightly higher entry speed than urban roundabouts. See FHWA Roundabout Guide Exhibit 6-14 for additional information.

Be aware of entry and exit path overlap. Avoid tight exit radii to help reduce exit path overlap. The R1 and R2 should be used to control exit speed. Typically, the speed relationships between R1, R2, and R3 as well as between R1 and R4 are of primary interest. Along the through path, the desired relationship is $R1 > R2 < R3$, where R3 should not be less than R1. Similarly, the relationship along the left-turning path is $R1 > R4$.

For most designs, the R1/R4 relationship will be the most restrictive for speed differential at each entry. However, the R1/R2/R3 relationship should also be reviewed, particularly to ensure the exit design is not overly restrictive speed-wise. (Whereas design criteria in past years advocated relatively tight exit radii to minimize exit speeds, recent best practice suggests a more relaxed exit radius for improved drivability. It has been found that speeds at roundabout exits are still low due to R2 speeds and the short distance between R2 and the exit leg, rendering R3 practically irrelevant as a speed control.)

When designing complex multi-lane roundabouts or to check the design speed control of sensitive designs that may have high entering or circulating speeds or where the pedestrian activity is anticipated to be medium to high, check for a conservative design by determining the fastest speed paths using a 3.28 ft (1 m) offset to each of the critical controlling feature locations (i.e. raised curb face on the approach and exit median, curb face at the central island, or centerline pavement marking between opposing traffic).

Remove any reverse curvature between the entrance and exit radii and join the radii with straight curb sections. The entry width of a single lane entry will be dictated by truck movement needs. Slow entry speed control is dictated by the relationship of R1 and R2. This speed control is necessary to preserve pedestrian safety at both the entrances and exits. It may be desirable for operational and capacity reasons to provide a dual lane entry when the width must be 18 feet or wider, and consider increasing each entry lane to 11-foot width at the widest point. Experienced roundabout designers will have to determine where it is appropriate to provide a single lane entry wider than 18 feet.

30.5.4 FHWA Section 6.2.2, Design Vehicle

The standard design vehicle for the state highway system in Wisconsin is the WB-65 - even where they are not the designated design vehicle – is strongly recommended. There may be situations where community sensitive design considerations suggest that larger or smaller vehicle accommodations may be warranted. Additionally, usage or possible usage of the facility by unconventional vehicles (e.g. farm vehicles, OSOW network) must be researched and the design tailored to accommodate them accordingly.

The inscribed circle diameter, the width of the circulatory roadway and the central island diameter are interdependent: once any two of these are established, the remaining measurement can be determined. However, the circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles also play a significant role in accommodating the design vehicle and providing deflection. Although the standard vehicle is a WB-65, occasionally larger vehicles need to be accommodated. In such cases, the designer must also verify that approach widths and exit widths are sufficient where entry/exit curves result in off-tracking.

In order to ensure that light vehicles encounter sufficient entry deflection at normal roundabouts, a truck apron (i.e. a raised low profile area around the central island) is necessary. It should be capable of being mounted by the trailers of large goods vehicle, but unattractive to cars and SUV's.

The required width of the circulatory roadway is determined from the width of the entries and the turning requirements of the design vehicle. In general, it should always be at least as wide as the maximum entry width (up to 120 percent of the maximum entry width). Depending on the design, the width may or may not remain constant throughout the roundabout. There are situations with low side road traffic where a portion of the circulatory roadway width may be narrower to accommodate a lower traffic volume.

At multi-lane roundabouts where the circulatory roadway is wide, accommodating the design vehicle is usually not a constraint unless the designer chooses to allow side-by-side passage of a car and a truck. This can occur when the percentage of trucks is high and/or when the roundabout has lanes marked and defined in the circulatory roadway. For multi-lane roundabouts rarely do trucks track within lanes that are marked on the circulatory roadway. In such cases the designer must consider lane widths and overall circulatory width

checking for vehicle swept paths under the following conditions:

1. Trucks in the outside lane and passenger car on the inside lane. Inscribed circle diameter affects the width of lanes and in some cases lanes cannot be made wide enough to be practical. In such cases, over-tracking of the lane lines is inevitable. The designer must decide whether to accommodate two vehicles because the percentage of trucks is high or maintain narrower circulatory lane widths to make it obvious that trucks will overlap lane lines.
2. Trucks on the inside lane can use the truck apron but don't always do so as observations reveal. Again, making the circulatory roadway wide enough to accommodate the two vehicles must consider circle size and choice of lane widths.

In all cases, the designer will test swept paths and iterate through combinations of circle size, lane widths on the circulatory roadway, truck apron width is 12-feet minimum but may need more width in special situations or on the OSOW Freight Network. In the case of three lane entries off-tracking is assumed to overlap lane lines unless the designer provides for high volumes of large trucks.

See [FDM 11-25-1](#), Part 1.1 and [FDM 11-26-10](#), Part 10.22 for additional information on OSOW routes and vehicles.

30.5.4.1 Other Considerations for Large Vehicles

Observations are showing that semi trucks entering a dual lane roundabout take up both lanes at the entry therefore not allowing any cars to travel beside the truck in the circulatory roadway. Some roundabout entry designs have a space between the lanes, or gore area separating the lanes, to allow a semi to stay in-lane at the entry. Depending on the angle of entry and the size of a roundabout a truck may travel completely in the outside lane with sufficient room for another vehicle to travel next to the truck. In cases where truck volumes are noticeably high it may be necessary to post a warning sign. No other vehicles should drive next to or pass a truck in a roundabout. Observations have shown that in almost all instances where a car and truck were side-by-side, the smaller vehicle tended to accelerate ahead of the truck or would slow down to get behind the truck.

A secondary consideration associated with large trucks in roundabouts is the potential for overturning or shifting loads. There is no simple solution in relation to layout geometry to completely prevent load shifting and roll-overs. Load shifting, or worse load shedding, may lead to property damage and congestion and delay and is expensive to clear, especially if it occurs at a major roundabout. Experience suggests that at roundabouts where these problems persist, there are frequently combinations of the following geometric features:

- Long straight high speed approach;
- Inadequate entry deflection or too much entry deflection;
- Low circulating flow combined with excessive visibility to the right;
- Significant tightening of the turn radius partway round the roundabout (spirals with arcs that are too short).
- Cross-slope changes on the circulatory roadway or the exit; and,
- Outward sloping cross-slope on the inside lane of the circulatory roadway

A problem for some vehicles may be present even if speeds are low because of a combination of grade, geometry, and sight distance and driver responsiveness. Research has shown that an articulated large goods vehicle with a center of gravity height of 8 feet above the ground can overturn on a 65 foot radius curve at speeds as low as 15 mph. See TRL Report LR788.

Layouts designed to mitigate the above noted characteristics will be less prone to load shifting or load shedding. In addition, pay attention during design and construction to ensure that pavement surface tolerances are complied with and that abrupt changes in cross-slope are avoided.

30.5.5 FHWA Section 6.2.3 Non-motorized design users

The splitter island minimum width is 6 feet (face of curb to face of curb) desirable is 8 feet, within the pedestrian refuge area. The minimum crosswalk width in the splitter island, outside to outside of white edge line, is 7 feet, desirable is 10 feet. See FHWA Roundabout Guide, Exhibit 6-26.

30.5.6 FHWA Section 6.2.4, Alignment of approaches and entries

The key factor in roundabout design is deflection at entry, which has nothing to do with centerlines of roadways. It is not good practice to generate entry deflection by sharply curving the approach road to the left close to the roundabout and then to the right at entry. Adherence to the principles of deflection is crucial to the operation and safety of roundabouts. WisDOT considers this design element to be of the utmost importance.

FHWA Roundabout Guide Exhibit 6-18 and accompanying text generally do not represent valid policy for

roundabouts. Centerlines of roadways do not need to pass through the center of the inscribed circle. It is acceptable design practice (especially in multi-lane roundabouts) to provide an offset to the left of the center of the central island. In some situations it may be appropriate to provide an offset of 40 to 60 feet between opposing entries, or a distance as shown in [Figure 30.3](#) (approximately 20 to 30 feet left of the center of the central island) to achieve proper deflection and appropriate fastest path R1 speeds.

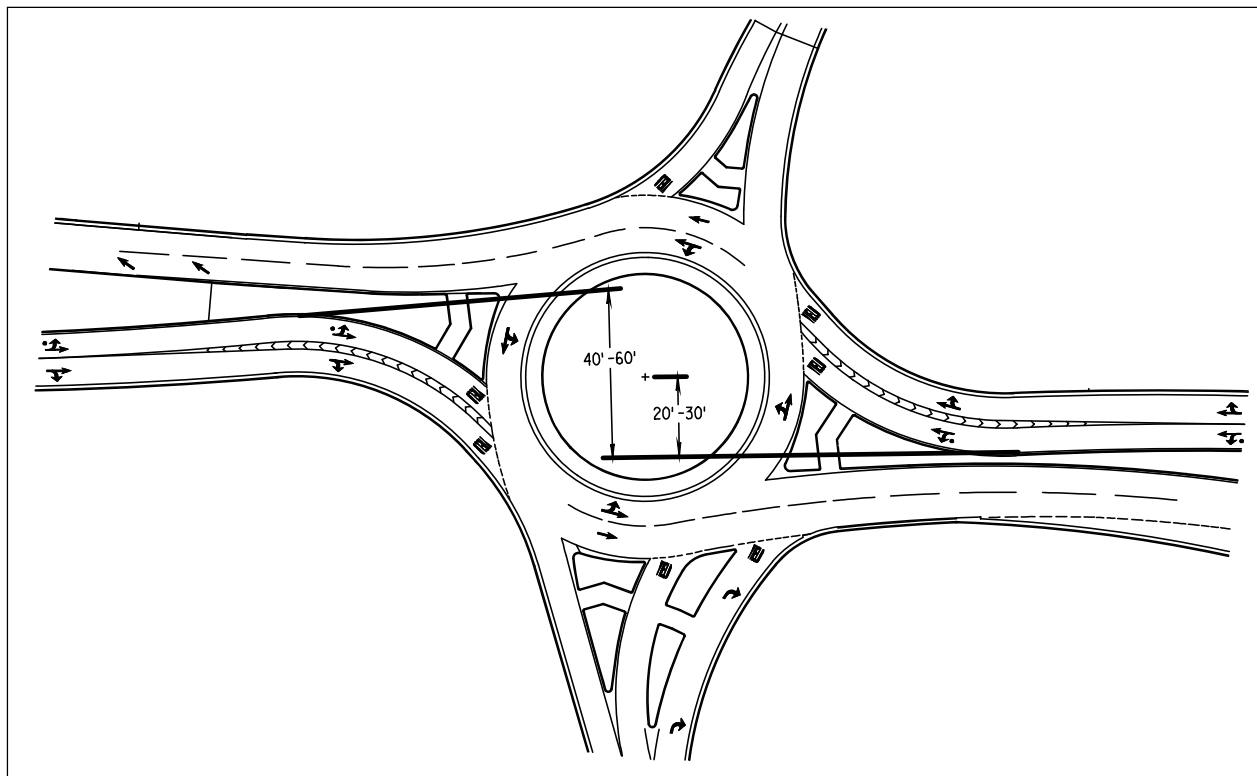


Figure 30.3. Entry Deflection

30.5.7 FHWA Section 6.3.2, Entry width

Is measured perpendicularly from the outside curb face to the inside curb face at the splitter island point nearest to the inscribed circle.

Narrow entries tend to promote safety. However, a WB-65 may require an 18 to 22 foot wide entry path for single lane approaches, depending on skew angle, to be able to make a right turn. Design a single lane roundabout that will accommodate a WB-65 where the truck tractor will not encroach onto the truck apron. Wide entries may cause concerns about whether to pavement mark the entry as a multi-lane or keep as a single lane. Increasing the effective flare length (L') or entry width (E) will increase capacity. Increasing both may produce a dramatic increase in capacity. Effective flare length may be as short as 15 feet or as long as 330 feet. Once the effective flare length exceeds 330 feet it will begin to have a minimal impact to increase capacity and adding a full approach lane would be advised.

30.5.8 FHWA Section 6.3.3 Circulatory roadway width

The circulatory roadway width does not need to remain constant. A two-lane entry may be appropriate for the major through highway. However, the minor side road may be single lane approaches. The circulating roadway may often have a different width to accommodate the through traffic than for the side road traffic.

30.5.9 FHWA Section 6.3.4 Central island

The central island of a roundabout is always a raised, non-traversable area encompassed by the circulatory roadway; this area should also include a traversable truck apron. The island is raised and landscaped to enhance driver recognition of the roundabout upon approach and to limit the ability of the approaching driver to see through to the other side of the roundabout. The inability to see through the roundabout reduces or eliminates headlight glare at night and driver distraction by other vehicles on the circulating roadway.

The center or highest portion of the central island ground surface elevation should be raised approximately a minimum of 3.5 feet and approximate maximum of 6 feet from the circulatory roadway surface. The ground slope in the central island shall not exceed 6:1.

Concrete, stone, wood or other non-forgiving material used to make a wall within the central island is prohibited. Landscaping the central island and the roundabout area is further addressed in [FDM 11-26-40](#).

The outside 6 feet of the central island should be a low mowed grass surface or low maintenance surface to maintain good visibility to the left upon entry, good forward and circulatory visibility on the circulatory roadway.

30.5.10 FHWA Section 6.3.5 Entry curves

The minimum entry radii should be approximately 65 feet. Capacity will increase with increased entry radii, but so will the entry speed.

Entry radius is not R1. It should be noted that R1 should be greater than R2 as stated previously, not as stated in the FHWA Roundabout Guide.

30.5.11 FHWA Section 6.3.8, Splitter islands

WisDOT prefers the distance from the yield point to the crosswalk to be one car length or approximately 20 feet instead of 25 feet as shown in the FHWA Roundabout Guide Exhibit 6-26.

Splitter islands should generally be crowned upward with a slope toward the center of the island area using between a 4 percent slope to as much as a 6:1 slope. The maximum overall height above the top of the curb within the splitter island area should be approximately 18 inches to the top of any concrete/asphaltic surface or to the top of mature low growth vegetation from top of curb. Some islands may become quite wide near the circulating roadway however limit the height to 18 inches. The approach nose separating the entering traffic and the exiting traffic shall be a Concrete Median Sloped Nose, Type 1. This splitter island nose Type 1 should be 6-foot face-to-face where the R4-7 (keep right) sign typically is located. The other 2 noses at the edge of the circulatory roadway and the splitter island shall be a Concrete Median Sloped Nose, Type 2. Both nose types are shown in SDD 11B2. Where there is a divided highway approaching the roundabout the approach nose is eliminated. A typical splitter island exhibit is shown in [Figure 30.4](#).

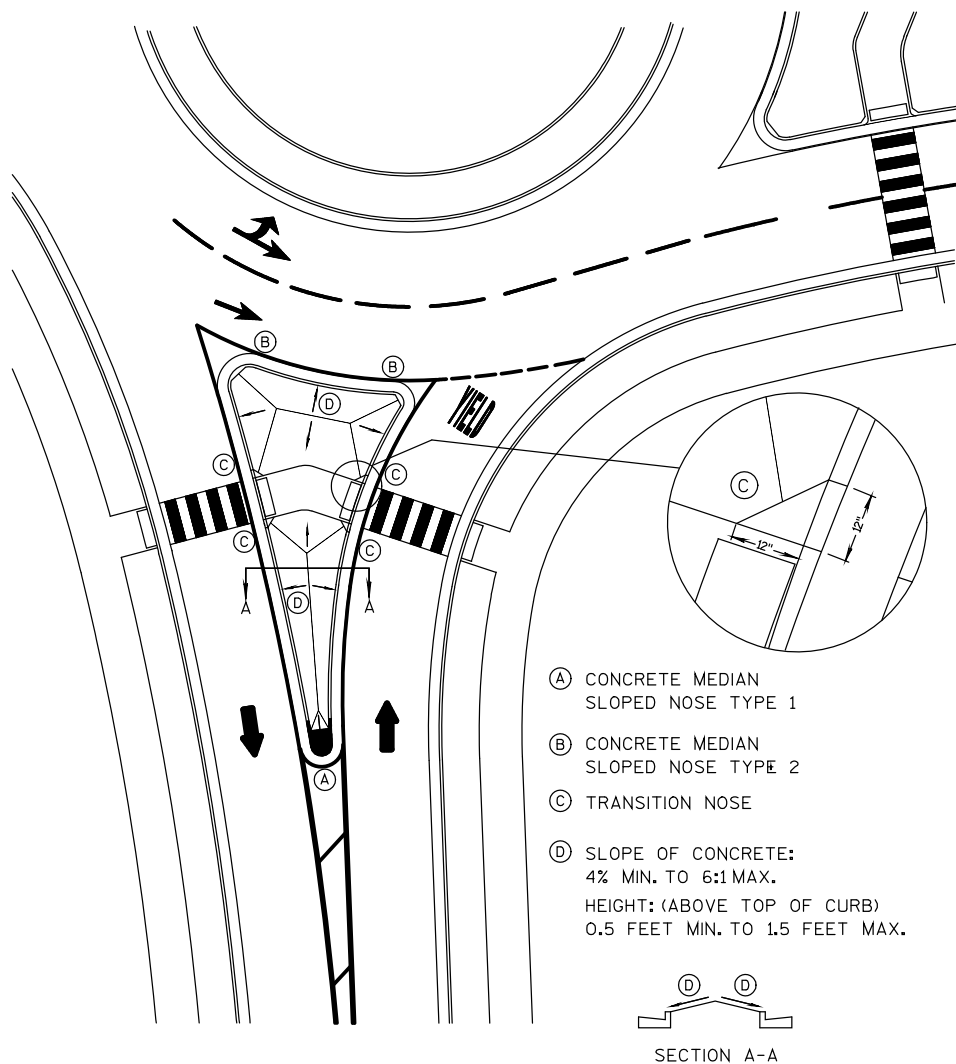


Figure 30.4. Typical Splitter Island

30.5.12 FHWA Section 6.3.10.2, Length of conflicting leg of sight triangle

See NCHRP Report 672 starting on page 6-63 for guidance on Intersection Sight Distance (ISD) for roundabout approaches. The basis for ISD in NCHRP Report 672 is providing the critical headway time gap (t_c) for entering the roundabout.

The critical headway time gap (t_c) for entering the roundabout is based on the amount of time required for a vehicle to safely enter the conflicting stream. If the perceived available headway time gap is less than t_c then most drivers will slow down or stop and wait for an acceptable gap. The critical headway time gap (t_c) equals 5 seconds as stated in NCHRP Report 672. This is less than the 6.5 second required by the 2000 FHWA Roundabout Guide, but greater than the previous FDM requirement of 4.5 seconds. [Table 30.4](#) shows computed distance for various speeds based on a critical headway time gap (t_c) = 5.0.

Table 30.4 Roundabout Intersection Sight Distance

Conflicting Approach Speed (mph)	* Computed Distance (ft) for tc = 5.0s
10	74
15	110
20	147
25	184
30	221

*distance in feet = speed (mph) multiplied by time (seconds) multiplied by a factor of 1.468.

The “clear sight window” requirements for critical headway time gap (tc) are shown on Exhibit 6-58 of NCHRP Report 672. Use an eye height above the roadway surface of 3.5 feet for passenger cars and 7.6 feet for trucks in establishing sight lines through a clear sight window. Use an object height above the roadway surface of 3.5 feet. See [FDM 11-10 Figure 5.2](#) for guidance on the vertical boundaries of a “clear sight window”.

[Figure 30.5a](#) shows “Normal ISD” for a roundabout approach; [Figure 30.5b](#) shows “Minimum ISD” for a roundabout approach. Use the following guidance when designing the ISD “clear sight window” for a roundabout approach:

- **[Normal ISD & Minimum ISD – driver’s eye position on approach]** Set the initial position of the driver’s eye at 50 feet behind the yield line, as depicted on Exhibit 6-58 of NCHRP Report 672, and as shown in [Figure 30.5a](#) & b for the vehicle approaching on Leg 2.
- **[Normal ISD & Minimum ISD - to circulating roadway]** Provide ISD based on [tc=5.0 seconds X “circulating speed X factor”] for the circulating stream distance d2, as depicted on Exhibit 6-58 of NCHRP Report 672, and shown on [Figure 30.5a](#) & b as the distance from point 2 to point 4. For example, if the circulating speed is 20 mph, the distance between point 2 and point 4, per [Table 30.4](#), is 147 feet.
- **[Normal ISD - to adjacent leg to the left]** Provide ISD based on [tc=5.0 seconds X “fastest path speed X factor”] for the entering stream distance d1, as depicted on Exhibit 6-58 of NCHRP Report 672, and shown on [Figure 30.5a](#) as the distance from point 1 to point 4. For example, if the “fastest path speed” is 25 mph, the distance between point 1 and point 4, per [Table 30.4](#), is 184 feet.
- **[Minimum ISD - to adjacent leg to the left]** It may not be possible to provide “Normal ISD” at some approaches because of a sight obstruction whose removal would cause unacceptable impacts. For these locations, provide ISD to at least 50-feet behind the yield line of the adjacent leg to the left - as shown on [Figure 30.5b](#). The resulting reduced entering stream distance d3 from point 3 to point 4 is less than [tc=5.0 seconds X “fastest path speed X factor”]. However, it is unlikely that all vehicles will be traveling at the “fastest path speed” between points 3 and 4 because some drivers will slow down or stop behind the yield line if there is an unacceptable gap.


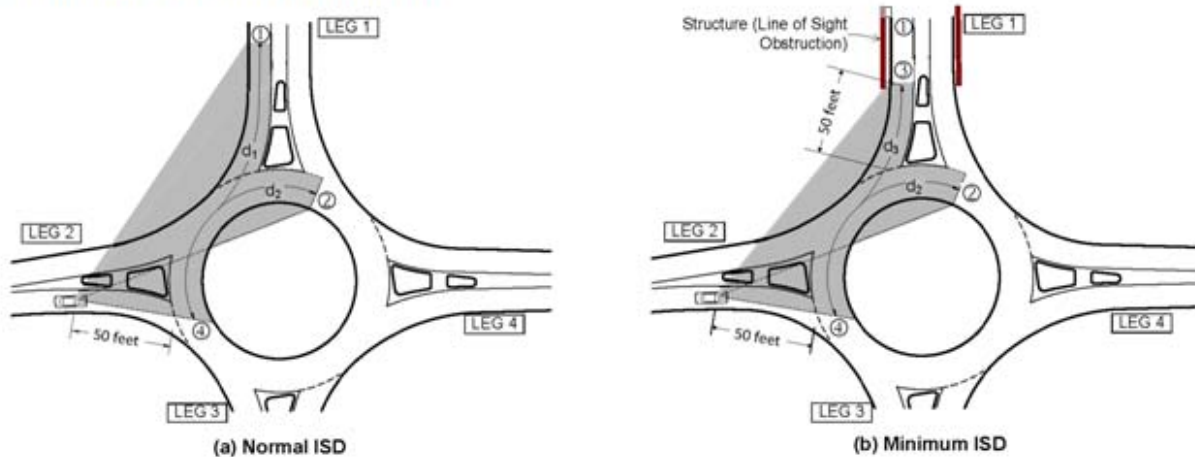
Legendd₁ Entering Stream Distanced₂ Circulating Stream Distanced₃ Reduced Entering Stream Distance starting at least 50-feet behind the Leg 1 yield line
 ISD Clear Sight Window for vehicle on Leg 2


Figure 30.5. Example of Roundabout ISD Clear Sight Window (Leg 2 ISD shown – other Legs are similar)

Designer experience and judgment is needed to balance the impacts where ISD is severely restricted or where excess ISD is available. More is not better when it comes to Intersection Sight Distance for roundabouts. British research on sight distance has determined that excessive intersection sight distance results in a higher frequency of crashes because excessive forward visibility at entry or visibility between adjacent entries can result in approach and entry speeds greater than desirable for intersection geometry.

Consider limiting visibility by the use of selective landscaping. This refers to landscaping or a visual block down the side road to restrict visibility between adjacent entries, as well as the forward visibility through the central island. Limiting visibility in this way helps encourage drivers to slow down on the roundabout approach, which provides a safer environment for both drivers and pedestrians.

30.5.13 FHWA Section 6.3.11.2, Superelevation

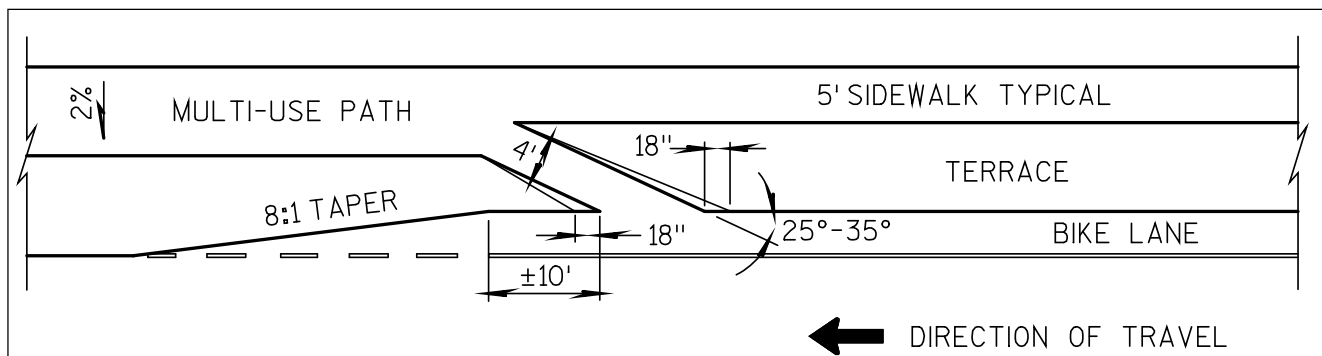
FHWA Roundabout Guide, Exhibit 6-37: When designing the circulatory roadway pavement cross section, consider the pavement type that will be used, asphaltic or concrete. Crown the roundabout 'circulating roadway' with a 2% cross slope with approximately 2/3 width sloping toward the central island and 1/3 width sloping outward. An alternative cross section may be to slope one half the width inward and one half outward. See section 6.1 for additional guidance on single and multi-lane roundabouts.

The preferred truck apron slope is between one and two percent toward the circulatory roadway. Greater than two percent slope should not be used on OSOW routes. However, it may vary between 1 and 4 percent when justified on other routes.

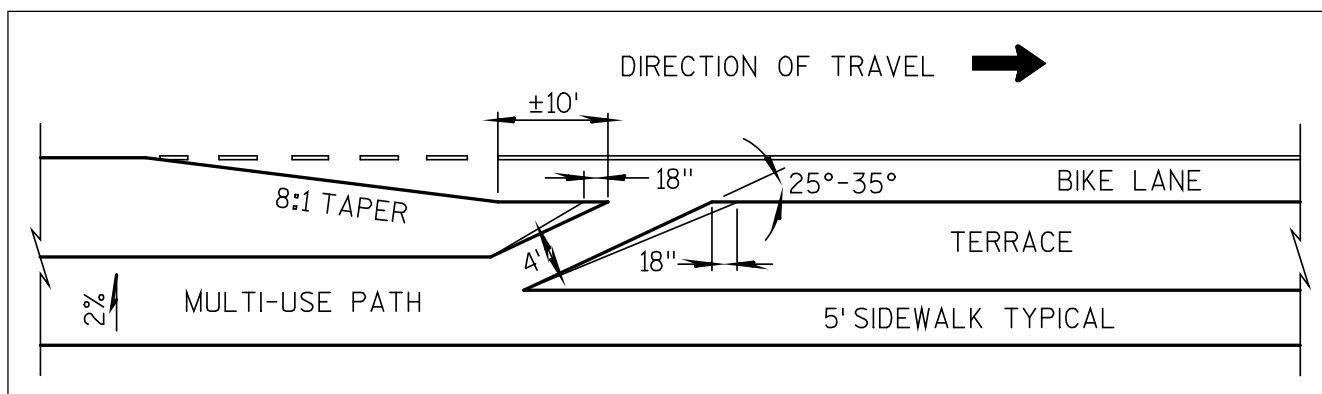
30.5.14 FHWA Section 6.3.12 Bicycle provisions

Design the bike ramps 4 feet wide between the roadway and the multi-use path such that they angle up (25 to 35 degrees) to the path where the bicycles exit the roadway, [Figure 30.6](#) (a). Angle down (25 to 35 degrees) toward the roadway where the bicycles re-enter the roadway, [Figure 30.6](#) (b).

Do not provide a perpendicular ramp between the two surfaces such that a bicyclist must stop, or nearly stop the forward motion to enter one facility or the other. All urban and suburban roundabout locations should include bicycle ramps between the roadway and a shared use path. When the shared use path is not installed with the initial construction then grade the perimeter of the roundabout for future path installation.



(a) Bike Ramp Exit



(b) Bike Ramp Entrance

Figure 30.6. Bike Ramp Entrance & Exit**30.5.15 FHWA Section 6.3.15 Right turn bypass lanes**

Two alternatives exist to provide for heavy right turn demand: The first is a free flow bypass lane, which allows vehicles to bypass the roundabout and then merge into the exiting stream of traffic. The second type is a semi-bypass or partial bypass lane, with or without a vane, which requires approaching vehicles to yield to traffic leaving the adjacent exit. A bypass lane allows vehicles to circumvent a roundabout, providing additional capacity. Typically, bypass lanes should only be used when other geometric layouts fail to provide acceptable traffic operations, and the decision to use bypass lanes should take into account pedestrian and ROW constraints. In some cases, bypass lanes provide significant benefits.

Choosing the proper alternative is dictated by the volume of right turns and the available space. A high right turn demand when coupled with other approaching traffic may indicate the need for a full bypass lane in order to avoid a wider, faster entry. The analysis of traffic flows in RODEL with and without the right turn flows will confirm this choice. A preliminary rule of thumb is to consider using a partial right turn with volumes under 500 vph and use a full bypass with volumes over 500 vph. If there are high pedestrian volumes try to avoid the use of full bypass lanes. This again should be reviewed in RODEL.

The FHWA Roundabout Guide illustrates two designs for full bypass lanes, Figures 6-42 and 6-43. Figure 6-43 design is flawed by poor sight distance for right turning drivers having to look left at an angle greater than 90 degrees. Figure 6-42 is preferred for a full bypass because the right turning traffic has an exclusive exit without conflicts between other exiting traffic provided that the merge distance is sufficient if the auxiliary lane is to be dropped downstream.

An alternative that maybe superior to Figure 6-43 is a partial right turn that still 'snags' the right turner from making a through movement while preserving good sight to the left for circulating/exiting traffic. A vane island can be used or simply markings depending on space, alignment, entry angle and need to improve the 'snagging' effect of the geometry. [Figure 30.7](#) shows the addition of a partial or 'snagged' bypass lane at the north leg of the roundabout. Note the other features that can accompany this treatment including narrowing of the downstream circulatory roadway by having the adjacent splitter island protrude into the circulatory roadway and the way the far right hand curb on the north approach is pulled off the inscribed circle to aid the separation

between entering /circulating traffic and the right turns.

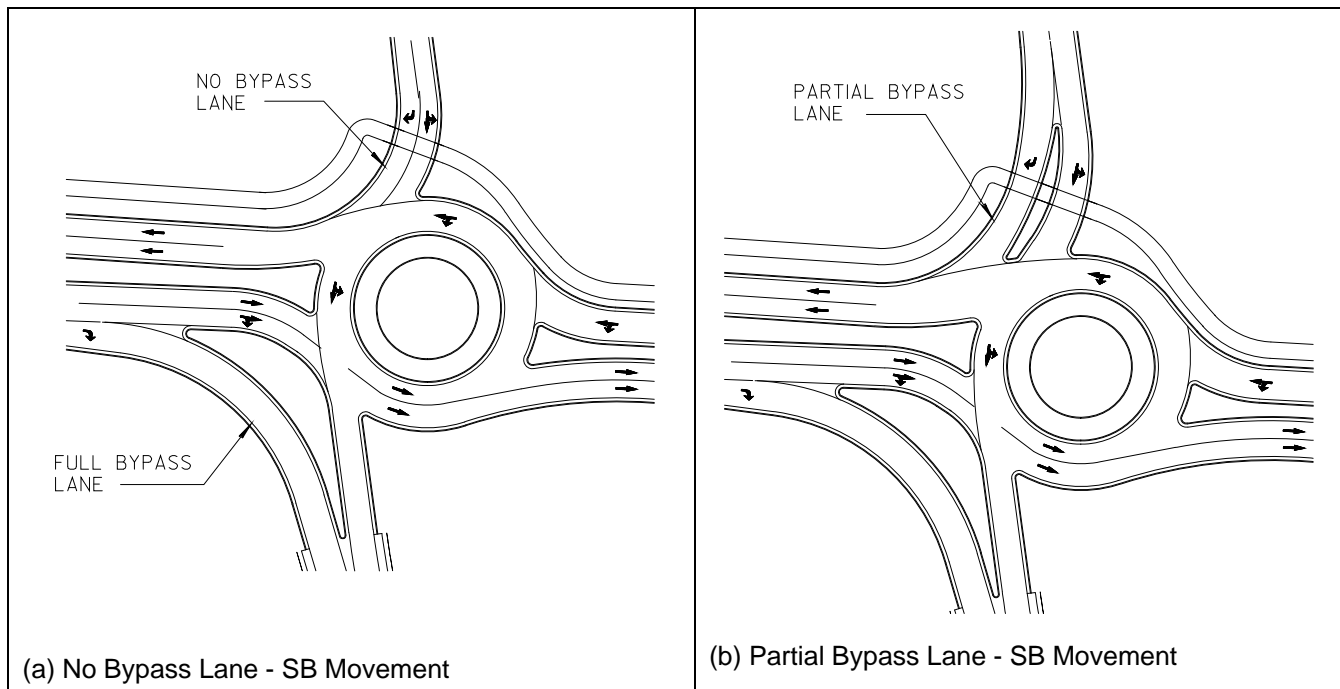


Figure 30.7. Right turn bypass lanes

30.5.16 FHWA Section 6.4.2 Vehicle path overlap and methods to avoid path overlap

Designing multi-lane roundabouts is significantly more complex than single-lane roundabouts. Factors include the additional conflicts present with multiple traffic streams entering, circulating and exiting the roundabout in adjacent lanes. The natural path of a vehicle is the path it will take based on the speed and orientation imposed by the roundabout geometry. While the fastest path assumes a vehicle will intentionally cut across the lane markings to maximize speed, the natural path assumes there are other vehicles present and all vehicles will attempt to stay within the proper lane.

Designers should determine the natural path by assuming the vehicles stay within their lane up to the yield point. At the yield point, the vehicle will maintain its natural trajectory into the circulatory roadway. The vehicle will then continue into the circulatory roadway and exit with no sudden changes in curvature or speed. If the roundabout geometry tends to lead vehicles into the wrong lane, this can result in operational or safety deficiencies.

Path overlap occurs when the natural paths of vehicles in adjacent lanes overlap or cross one another. It occurs most commonly at entries, where the geometry of the right-hand lane tends to lead vehicles into the left-hand circulatory lane. However, vehicle path overlap can also occur at exits, where the exit geometry or striping of the exit tends to lead vehicles from the left-hand lane into the right-hand exit lane. [Figure 30.7](#) illustrates an example of entry path overlap at a multi-lane roundabout. Here the left lane geometry directs the approach vehicle into the central island, while the right lane geometry directs the approach vehicle toward the inside circulatory lane., thus creating entry path overlap.

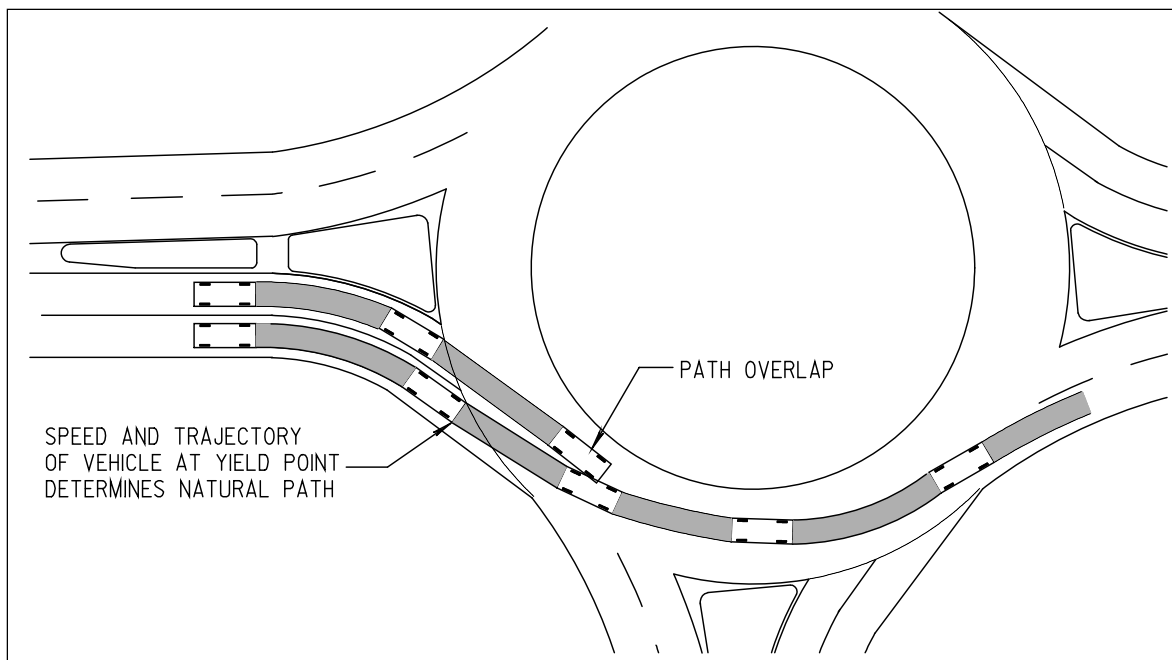


Figure 30.8. Entry Path Overlap

30.5.16.1 Method For Checking Path overlap

[Figure 30.9](#) provides a method for checking entry and exit path overlap. To avoid path overlap the desirable tangent length is 40 ft to 50 ft or two car lengths for the entry path tangent and 40 ft and greater for exit path tangent. The minimum tangent length to avoid entry and exit path overlap is 26 ft or one car length.

As a rule of thumb path overlap can be avoided if there is typically 5 feet between the face of the central island curb and the extension of the face of curb on the splitter island, see [Figure 30.9](#).

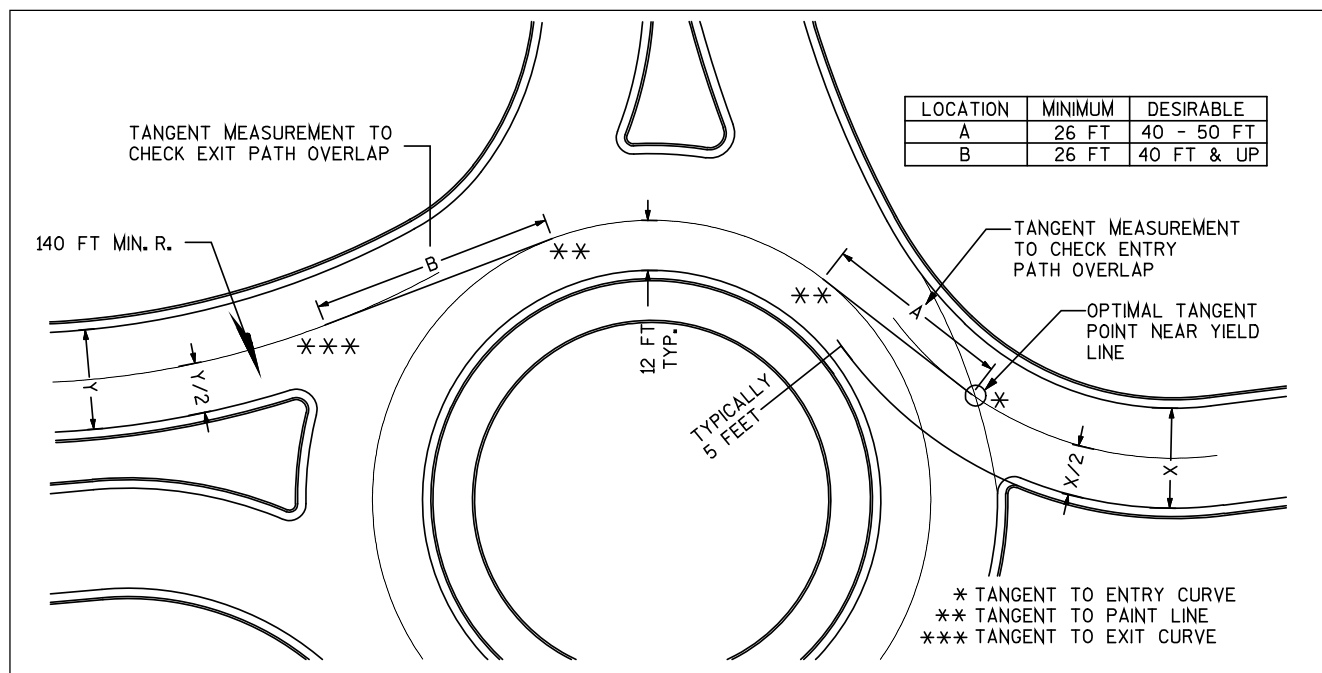


Figure 30.9. Method for checking path overlap

30.5.17 FHWA Section 6.4.3 Design method to avoid path overlap.

[Figure 30.10](#) shows the preferred method to avoid path overlap. This is more consistent with Roundabout Guide Exhibit 6-47 and is the preferred design for multi-lane entries. Start with an inner entry curve designed so when the edge of the splitter island curve is extended across the circulatory roadway the line is tangent to the central

island as shown. Once the lane geometry is determined to avoid path overlap then design the adjacent lane(s). The small radius entry curve will vary depending on the approach geometry and the fastest speed path but will typically range from 65-110 feet. A large-radius (greater than 150 feet) curve is then fitted between the entry curve and the outside edge of the circulatory roadway.

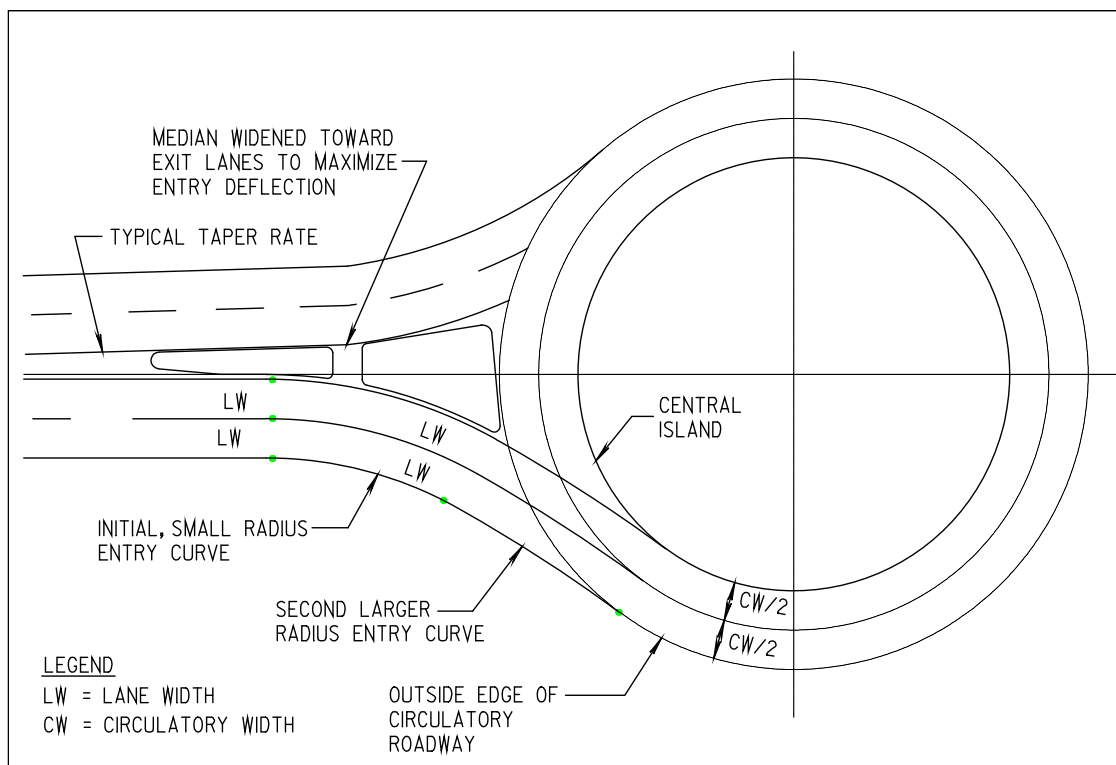


Figure 30.10. Design Techniques to Avoid Path Overlap

A second method is to start with a larger sweeping inner curve and provide a smaller radius curve near the approach that is tangent to the central island. This method is also described in the FHWA Roundabout Guide, Section 6.4.3.1.

The primary objective of this design technique is to locate the entry curve at the optimal placement so that the projection of the inside entry lane at the yield point forms a line tangent to the central island. This inner curve design concept is essential for multi-lane design and is recommended for single lane entries as well. [Figure 30.11](#) illustrates the result of proper entry design.

The location of the entry curve directly affects path overlap. If it is located too close to the circulatory roadway, it can result in path overlap. However, if it is located too far away from the circulatory roadway, it can result in inadequate deflection (i.e. entry speeds too fast).

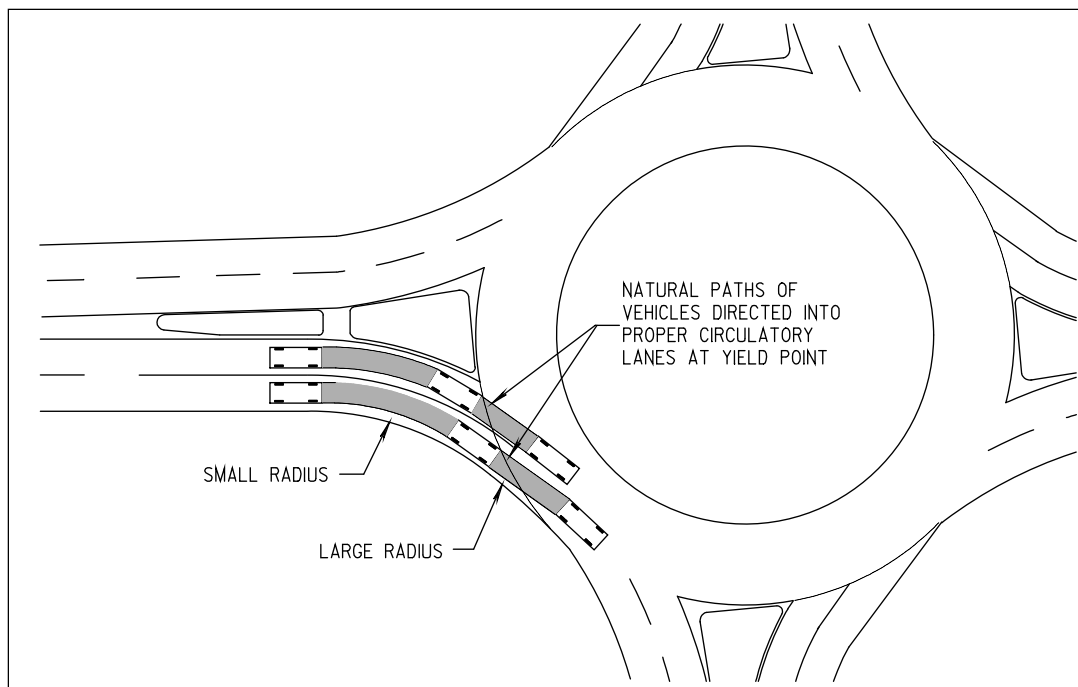


Figure 30.11. Multi-Lane Entry Design

30.5.17.1 Design Techniques to Increase Entry Deflection

Designing multi-lane roundabouts without path overlap while achieving adequate deflection to control entry speeds can be difficult. The same measures that improve path overlap issues generally result in increased fastest path speeds. One technique for reducing the entry speed without creating path overlap is to increase the inscribed circle diameter of the roundabout. Often the inscribed circle of a double lane roundabout must be 150-180 feet in diameter, or more, to achieve a satisfactory entry design. However, increasing the diameter will result in slightly faster circulatory speeds. Therefore, the designer is challenged to balance the entry speeds and circulatory speeds. This often requires much iteration of design, speed checks, and path overlap checks.

30.5.17.2 Approach Offset to Increase Entry Deflection

The technique of offsetting the approach alignment left of the roundabout center is effective at increasing entry deflection (see [Figure 30.3](#)). However, this also decreases the entry angle (ϕ), which if decreased too far can create reduced capacity, unsafe entry conditions, line of sight issues, unbalanced lane utilization, etc. It also reduces the deflection of the exit on the same leg, which will increase the fast path speed at the entry. Therefore, the distance of the approach offset from the roundabout center should generally be kept to a minimum to maximize its effectiveness in design and safety for pedestrians. A typical offset is 20 to 30 feet for center of inscribed circle diameter. Always remember that the fastest speed paths are a critical element of design.

30.5.18 FHWA Section 6.5.2 Curbing

30.5.18.1 Approach Curbs

Low speed approaches should incorporate 6-inch vertical face curbs in the area of the splitter island, on both sides of the roadway and on the splitter island. The purpose of the vertical face curbs is to control the fastest speed paths at the roundabout entrances and exits. Sloped 6-inch G/J Type curb and gutter may be used at the entrance to the roundabout and the exit from the roundabout. On the OSOW network a 4-inch G/J Type curb and gutter may be used in limited situations to better accommodate truck tires that may have to go over the curb or the splitter island.

High speed approaches to roundabouts usually occur where there is a rural cross section. This rural cross section for undivided highways will have shoulders without curb on the outside. When the highway is divided there will be shoulders on the inside, sometimes with sloped curbs, the outside will have shoulders typically without curb leading up to the roundabout. High speed approach design will require a transition section to the roundabout where the shoulders will narrow and vertical curb will be introduced. See [Figure 30.12](#) for an example of the high-speed approach layout. See "High speed Approaches at Roundabouts" ([FDM 11-26-30.pdf1](#)) by Scott Ritchie, RTE.

[Figure 30.12](#) shows the layout of the gore area for the beginning of the splitter island and the curb and gutter layout as the driver approaches the yield line. The painted gore area transitions into a raised curb median nose (Type 1) followed by a 4-inch sloping curb and gutter for a short distance as shown. The curb transitions in two ways as it approaches the roundabout. At the nose where the curb and gutter begins the curb face is 4 to 6 feet from the driving lane, or has a 4 to 6 foot shoulder on the left side of the approach. The shoulder narrows (according to the minimum shifting taper shown in [FDM 11-25 Figure 1.2](#) as the vehicle is anticipated to decelerate to 40 mph. [Figure 30.12](#) below does not address the needs for accommodating the OSOW vehicles on OSOW routes such as sloped curbs in the area of the roundabout entrance and roundabout exit. When the vehicle speed is anticipated to be 40 mph the 4-inch sloped curb and gutter transitions into a 6-inch vertical curb and gutter, in the last 5 feet of the deceleration length. Both curb and gutter types should have a 24-inch gutter, therefore the flow line and gutter flange are consistent.

In rural areas the painted gore and the curbs serve to alert the driver approaching a roundabout of the changing conditions and that a speed reduction is expected. Driver awareness that conditions are changing is accomplished through a combination of roadway curvature, channelization, lighting, landscaping, and signing. Total curb length starting from the yield line should be the deceleration distance required to reduce from the approach speed to the fastest path design speed (R1).

Example: The posted speed is 55 mph, and decelerating to approximately 25 mph produces a desirable total raised curb length distance of approximately 400 feet for the splitter island side of the roadway. Approximately 230 feet of that 400 feet is 4-inch sloped face curb and gutter and approximately 170 feet is 6-inch vertical face curb and gutter (may be 6-inch sloped face on OSOW network, or 4-inch sloped in limited situations). At a posted speed of 40 mph and decelerating to 25 mph produces a desirable total raised curb length of approximately 185 feet and all of the length is 6-inch vertical face curb and gutter (may be 6-inch sloped face on OSOW network, or 4-inch sloped in limited situations). Deceleration distance guidance can be found in the 2001 AASHTO GDHS, Exhibit 10-73, page 855. Use the posted speed as the AASHTO design speed. Differing approach conditions may produce different deceleration distances.

For the roundabout approach the minimum length of vertical face curb on the right side of the travel way should be the greater of; 25' prior to the bike ramp or 100' prior to the yield line (may be 6-inch sloped face on OSOW network, or 4-inch sloped). The vertical face curb installation will enforce the fastest speed path geometry.

The curb on the right side at the exit from the roundabout needs to be long enough to control exit speed and generally should be the greater of; 25' past the bike ramp or 100' past the exit measured from the ICD.

Consider drainage in the area of the curb/gutter by providing a flume or inlet structure.

30.5.18.2 Curb and gutter separating the circulatory roadway from the truck apron

Use Type R or T curb and gutter, 4-inch sloped, between the circulating roadway and the truck apron shown in [SDD 8D1](#). Use a Type T inlet casting on the drainage structure, as shown in [SDD 8A5](#). This curb and gutter is gentle to large truck tires, but should be unfriendly for SUV's and autos to traverse. When the circulatory roadway is concrete it shall be tied to the gutter flange with tie-bars. See [FDM 14-10-35](#) for pavement related topics.

30.5.18.3 Curb at the inside of the truck apron or edge nearest the central island

This curb may be a 6-inch vertical face or a 6-inch sloped face above the adjacent pavement surface. The adjacent pavement will be a concrete truck apron and sometimes it may be a concrete circulatory roadway or asphaltic circulatory roadway. Show this curb with tie-bars to the concrete truck apron on the plans. There may be situations when this inside curb could be deleted, but this is rare and should be addressed in the DSR.

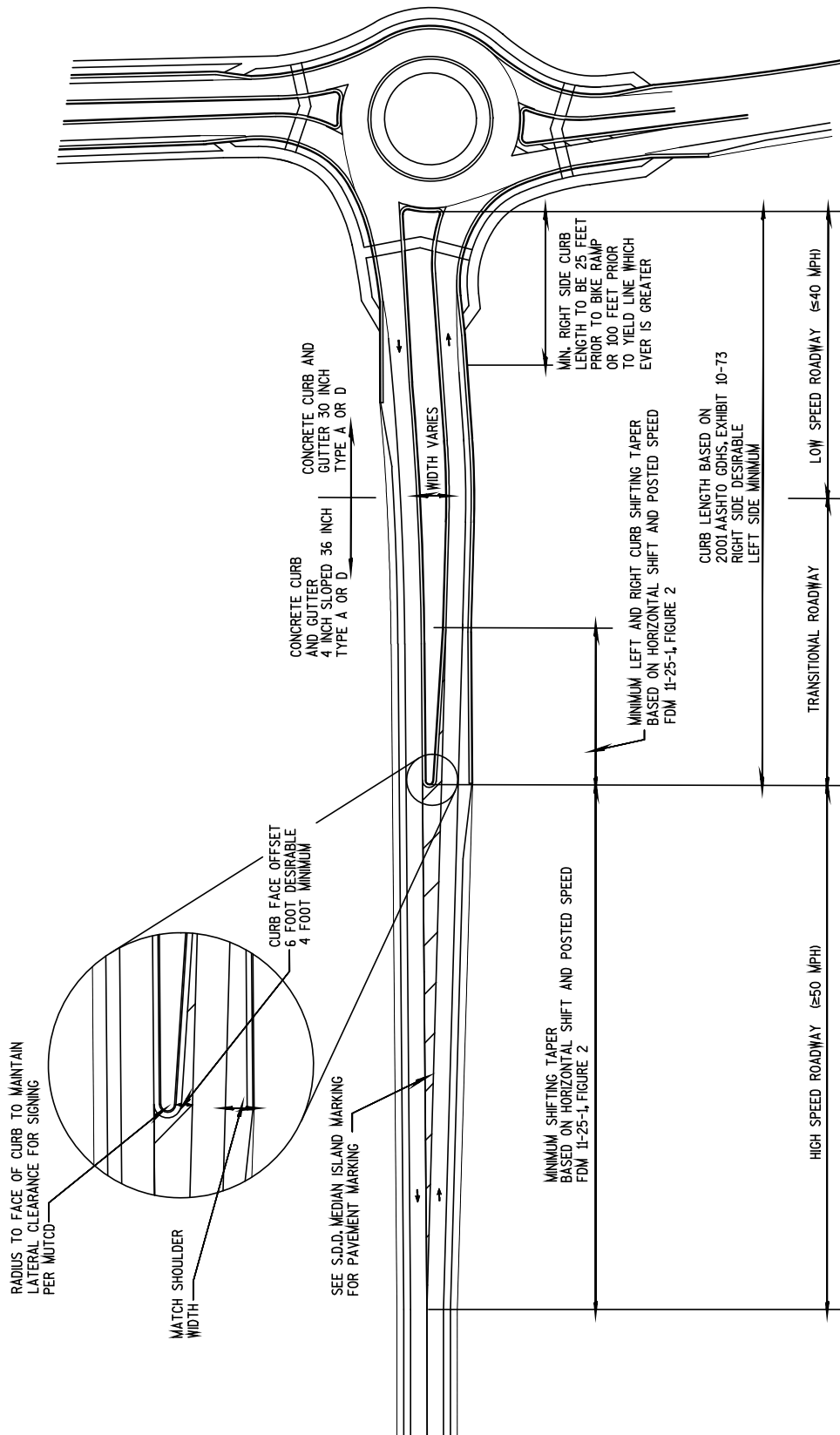


Figure 30.12. High Speed Roundabout Approach

30.5.19 Spirals

A spiral system involves a series of lane gains and lane drops around the circulatory roadway to lead drivers

into the appropriate lane for their desired exit. Spirals naturally guide drivers while maximizing the use of the circulating space and reducing potential conflict between adjacent vehicles. Spirals can also accommodate for heavily biased turning movements. Spirals should only be considered where the circulatory roadway has sufficient width to provide two or more lanes of traffic. Circulatory roadway spirals require considerable engineering judgment to design and locate properly.

A spiral may be developed from the central island by means of line markings, or curb and gutter until a full lane width is available. Typically, a curb and gutter spiral (or an extension of the central island) is preferred because it provides a 'hard surface' for vehicles to follow. Observations of spiral markings without a 'hard surface' indicate that some drivers ignore the pavement markings, which increases the potential for vehicle conflict in the circulatory roadway.

An example of a curbed spiral is shown in [Figure 30.13](#). This spiral is used to shift the westbound left turn to the outside lane. The spiral is used because the southbound exit is only a single lane exit and the southbound entrance allows dual left turns. To exit without conflict the westbound left turn would need to be spiraled to the outside lane. Without the spiral the left turn would be trapped on the inside lane and would do a u-turn or have to crossover lanes.

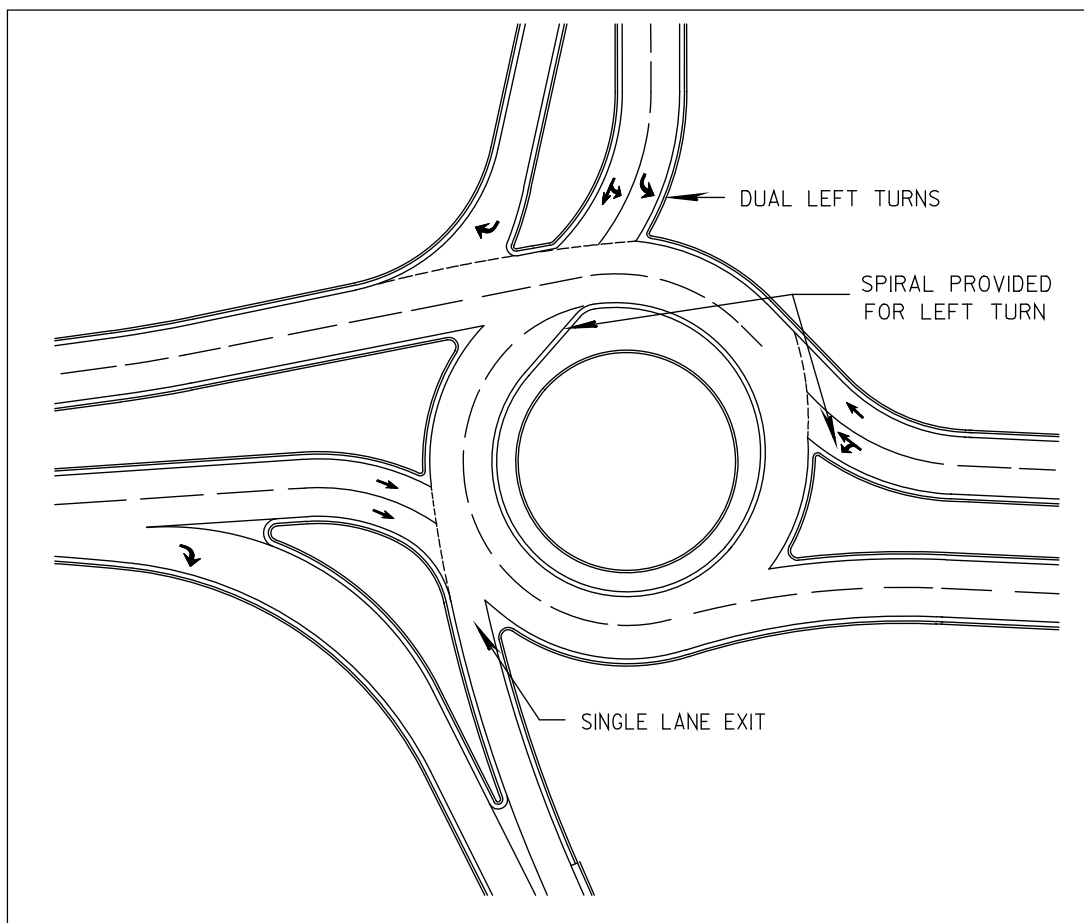


Figure 30.13 Spiral

30.5.20 Entry angle, phi

Phi is not discussed in the FHWA Roundabout Guide. This is one of the six key roundabout design parameters used in the British Empirical Method (TRL-LR 942) on which the RODEL software is based. This angle will not be a controlling design measure but is important for both capacity and safety at the intersection. A far more important concern is the fastest speed paths. Sometimes the designer may have to compromise the Phi angle to achieve the desired design result.

There are three situations or design conditions in which Phi can be measured. They are:

1. Condition 1: $\Phi = 2\Phi/2$ where the distance between the left sides of an entry and the next exit are NOT more than approximately 100 feet. In Condition 1, the acute angle is denoted as 2 PHI in which the actual value must be divided by two to obtain Phi (see [Figure 30.14](#), method 1).

2. Condition 2: $\Phi = \Phi$ if the distance between the left sides of an entry and the next exit are more than approximately 100 feet (see [Figure 30.15](#), method 2).
3. Condition 3: Applicable when an adjacent exit does not exist or an exit located at such a distance or obtuse angle to render the circulatory roadway a dominating factor of an entry (such as in a “3-leg” intersection). Φ is now the angle formed by the intersection of the tangent line (a-b) projected from the midpoint of the entry width with a tangent line (c-d) drawn along the middle of the circulatory roadway. Used at “T” intersections or where the adjacent entrance and exit lane(s) are far apart (see [Figure 30.15](#), method 2).

The two methods of measuring Φ are described below in [Figure 30.14](#) and [Figure 30.15](#). The typical range for the Φ angle is between 20 and 40 degrees with 30 degrees being the optimal, although there are designs that operate safely and efficiently with a Φ angle as low as 16 degrees.

Method 1 Φ is measured by dividing the entry and exit radii into three segments. The midpoint of the lane for each segment is best fit with a curve that extends to the face of curb of the splitter island extended. Begin line (a-b) and (c-d) at the intersection of the best fit arc and face of curb of the splitter island extended. Line (a-b) and (c-d) are then projected tangent from the best fit arc towards the circulating roadway, the angle formed by the intersection of the two lines is twice the value of Φ see [Figure 30.14](#).

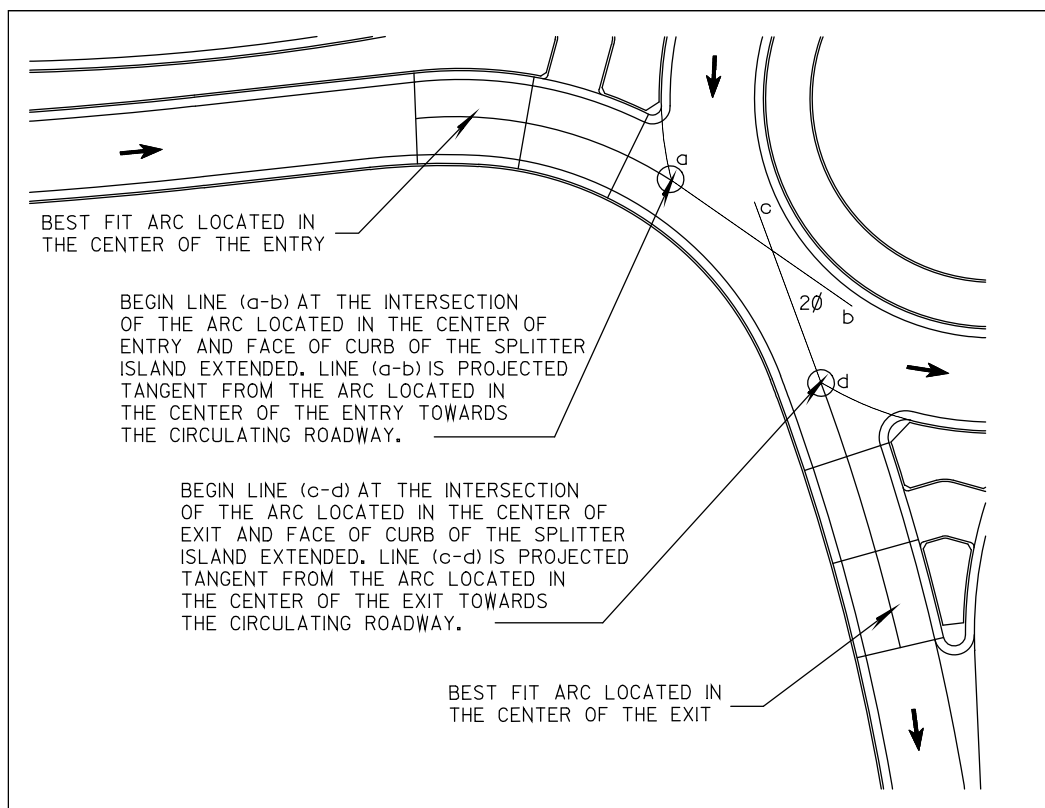


Figure 30.14 Method 1 Phi Measurement

Method 2 Φ is measured by dividing the entry radii into three segments. The midpoint of the lane for each segment is best fit with a curve that extends to the face of curb of the splitter island extended. Begin line (a-b) at the intersection of the best fit arc and face of curb of the splitter island extended. Line (a-b) is then projected tangent from the best fit arc towards the circulating roadway. Begin line (c-d) at the intersection of line (a-b) and the arc located at the center of the circulating roadway. Line (c-d) is then projected tangent from the arc located in the center of the circulating roadway. The angle formed by the intersection of (a-b) and (c-d) is Φ .

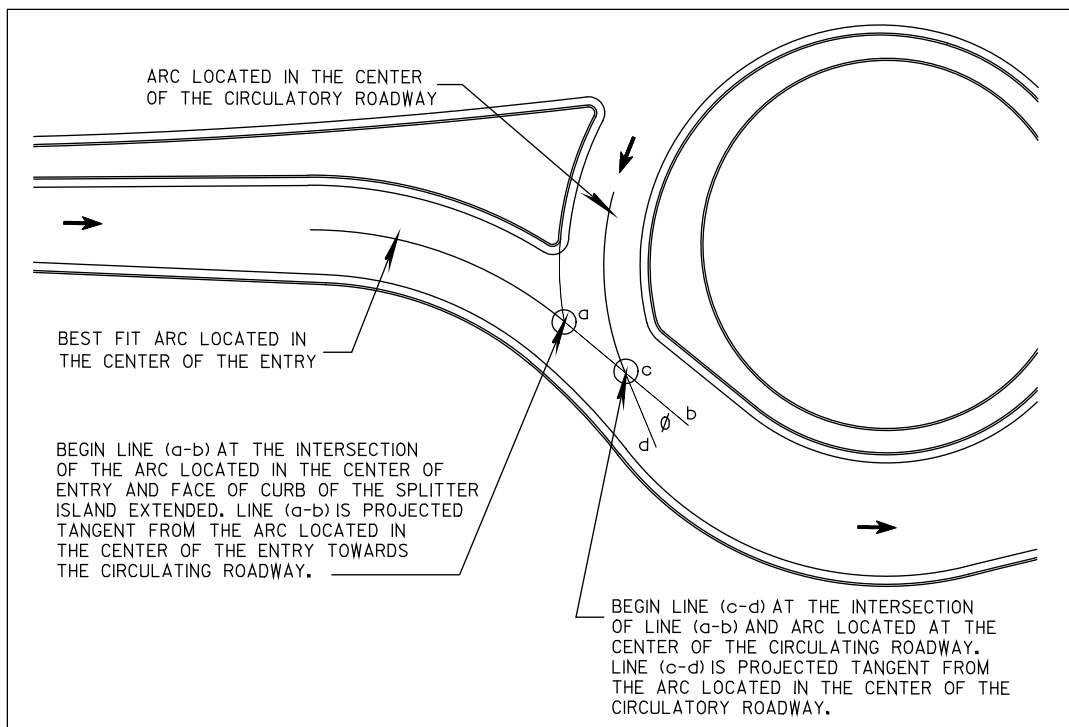


Figure 30.15. Method 2 Phi Measurement

30.5.21 Average Effective Flare Length = L'

The average effective flare length is shown in [Figure 30.16](#) (Source: Ourston Roundabout Engineering). The average effective flare length is the length of a curved line from c to f. Point c is half the distance between b and d. Line ad is entry width E and is measured perpendicular to the curb face. The length of line gh is $(E + V)/2$, the length of line bd is $(E - V)$, and the length of line cd is $(E - V)/2$. Line ab is equal to line gf is equal to V.

The average effective flare length is NOT the total length of flare between V and E, and is not always half the distance between V and E. Effective Flare is not discussed in the FHWA Roundabout Guide.

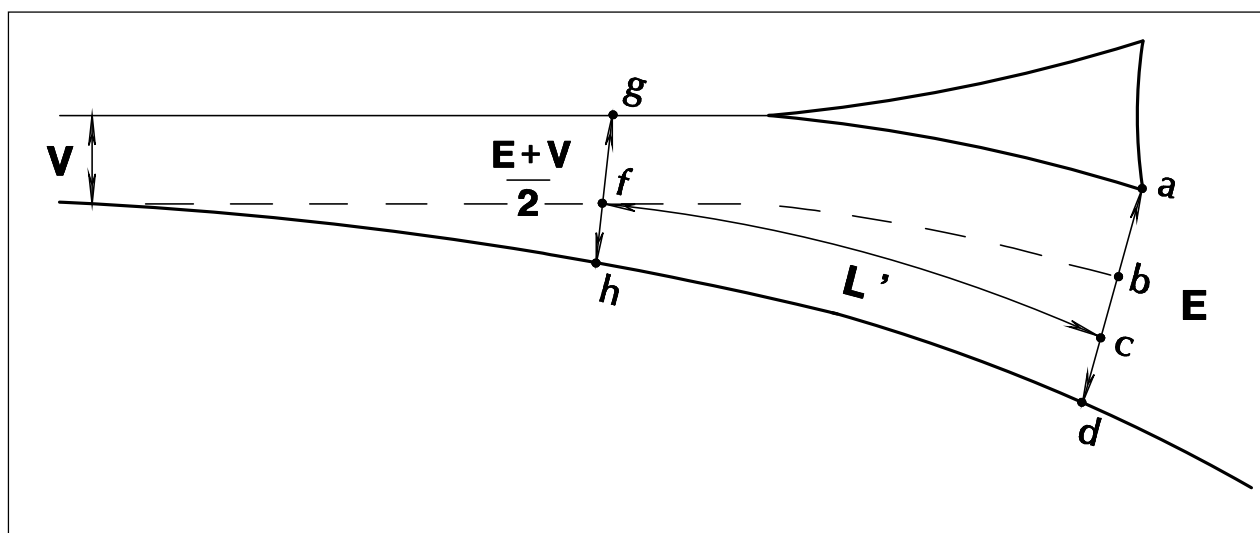


Figure 30.16. Average Effective Flare Length

30.5.22 Sharpness of Flare = S

Sharpness of Flare is not discussed in the FHWA Roundabout Guide. The Sharpness of Flare (S) can assist in the "effectiveness" of a flare $[S = 1.6(E - V)/L']$. Large values of S correspond to short, severe flares, and small values of S correspond to long, gradual flares that may have less effect on the average effective flare length.

30.5.23 Clear Zone

Clear zone guidance for roundabout installations requires consideration of the approach speeds, fastest path speeds, adjacent side slopes leading into and through the roundabout, and average daily traffic on the facility. The guidance for the determination of clear zone is provided in the current AASHTO Roadside Design Manual and [FDM 11-15-1](#), Figure 9 and 10.

The vehicle speed approaching an intersection and the speed allowed through an intersection, along with the ADT and side slopes, will determine the required clear zone. A traffic signal controlled intersection allows vehicles to go through the intersection at the posted speed, does not require the vehicle to reduce speed as it approaches the intersection, and therefore the clear zone should be maintained through the intersection. A stop sign controlled intersection located in a high speed rural condition will require less clear zone as the vehicle slows down to stop. As the approaching vehicle reduces speed it may be appropriate and desirable to reduce the corresponding clear zone. The designer has the responsibility to balance the need for clear zone and right-of-way acquisition.

The yield condition for a roundabout and the fastest path design speed approaching and traveling through the roundabout are similar to the stop sign controlled intersection. The horizontal geometrics leading to and through the roundabout intersection requires the vehicle to slow down leading to the approach and through the roundabout. The approaching speed transition distance for a roundabout is determined by the posted highway speed and the deceleration needed to enter the roundabout in accordance with the fastest speed path calculation, R1 value. Section 5.18.1 and [Figure 30.12](#) show how to determine the roundabout approach layout for high-speed highways. The design speed to use for clear zone around the perimeter of the roundabout is the average of the entry speed (R1) and the circulating path speed (R2) values. The maximum average entry speed (R1) and circulating speed (R2) for any type of roundabout is approximately 25-30mph. The average fast path, $[(R1 + R2)/2]$, of approximately 25-30mph will produce a clear zone between 7 and 18 feet depending on ADT. The exit ramps from an interchange are also considered to be low speed in close proximity of the approach to the roundabout. In an urban environment lateral clearance is typically used rather than clear zone to determine the minimum distance to fixed objects such as power poles, light poles, fire hydrants, trees etc. In a rural environment it is typical to use a clear zone based on the design speed, ADT and slopes. The side slopes adjacent to a roundabout are generally quite flat to accommodate a small terrace and a multi-use path around the perimeter. When the multi-use path is not installed at the time of the roundabout the area should be graded such that at some time in the future the path could be installed. The side slopes in the approach area having an approach speed of 40mph or less and the perimeter of the roundabout, outside of the multi-use path, should be 4:1 (recoverable slope) but may be steeper depending on meeting the clear zone requirement and local impacts.

Central island clear zone is considered to be within a low speed environment therefore needs to meet the lateral clearance for urban streets, typically 2 feet back from the face of curb. Having stated this WisDOT believes there are precautions, which are dependent upon the approach speed that need to factor into the central island landscaping design. See [FDM 11-26-40](#), for additional guidance on central island landscaping.

30.5.24 Coloring and Stamping concrete

The truck apron shall be reddish colored concrete and not stamped. **Use the bid item** that has been developed for the truck apron colored concrete. Contact the Region Office Materials Section for a WisDOT red colored concrete referee sample and a copy of the SPV. It is intended that the referee sample color will be in close conformance to the field installation.

For sidewalks that are colored use a reddish colored concrete sidewalk. Colored sidewalks are a community and designer agreed upon preference. Do not stamp sidewalks or crosswalks that will result in an uneven surface as this may aggravate back injuries or violate other ADA considerations. Refer to 2009 MUTCD Section 3B.18, and the WMUTCD, for additional information on marking crosswalks and use of reflective materials. The colored concrete sidewalk could be used for terrace areas and may be stamped, if not a walking surface, but stamping must be specified in the special provisions. Colored or uncolored concrete in the terrace adjacent to the corner radii where there is the possibility of truck off-tracking and riding over the concrete terrace shall be 6-inch thickness or thicker depending on anticipated loading.

See [FDM 14-10-35](#) for additional information relating to colored concrete, pavement design, tie bar location, dowel bar location, contraction joint layout. and other pavement guidance.

30.6 Terrain

Roundabouts typically should be constructed on relatively flat or rolling terrain with an approach grade that is desirably less than 3%, but not greater than 5%. Grades approaching 4% and steeper terrain may require greater transitions to provide an appropriate grade through the intersection. The grade through the intersection should generally not exceed 4%. See FHWA Roundabout Guide section 6.3.11.

For purposes of this text the roundabout is broken into two main components, the 'Circulating Roadway' (diameter) and the 'Approaches and Departures' (intersection legs).

30.6.1 Circulating Roadway (diameter)

It is generally desirable from a drive-ability and safety perspective to design and construct the circular component of the roundabout in one plane (planar). An example of this is to imagine a circular plane (dinner plate) that is placed onto the site and swiveled about its center point to optimize the 'fit' with existing topography. This will produce a 'high point' and a 'low point'.

- Single Lane Roundabout – crown the roundabout circulating roadway with a 2% cross slope with approximately 2/3 width sloping toward the central island and 1/3 width sloping outward
- Multi-lane Roundabout - Same crown guidance applies where possible. However, when you consider factors such as paver screed width, contraction joint location for concrete pavement, pavement marking location, and the total width of the circulatory roadway it is a challenge to comply with the 2/3 sloping inward and 1/3 sloping outward. Therefore another alternative (independent of material type) on dual lane roundabouts is to slope the inside lane, or left lane, toward the central island and slope the outside lane (typically wider lane) to the outside. This alternative will allow the contraction joint on concrete pavement to generally coincide with the lane line pavement marking and allow asphalt pavement roundabout to be similar in design. On triple lane roundabouts it may be possible to slope the 2 inside lanes toward the central island and slope the outside lane to the outside.

The crown vertical design feature provides good drivability, keeps water from draining across the circulating roadway which is particularly important in a northern climate with freeze-thaw cycles, and provides a smooth transition in/out of the approaches and departures. This 'crown' also reduces the probability of load shifting or truck over turning.

30.6.2 Approaches/departures (intersection legs)

The most critical vertical design area of the roundabout is the portion of roadway from the approach end of the splitter island to the circulatory roadway. This area requires special attention by the designer to ensure that the user is able to safely enter and exit the circulatory roadway. This area usually requires pavement warping or cross slope transitions to provide an appropriate cross slope transition rate through the entire transition area and within the circulatory roadway.

Entry grade profiles (approximately 2 car lengths from the ICD) are not to exceed 3%, with 2% being the desirable maximum. It is desirable to match the exit grades and the entry grades; however, the exit grade may be steeper but should not exceed 4%. Adjustments to the circulatory roadway cross slope may be required to meet these criteria, but should be balanced with the effects on the circulatory roadway. For a drawing of the preliminary cross section and layout refer to the FHWA Roundabout Guide, Chapter 6.

30.7 References

- [1] Roundabout Design Guidelines, Ourston Roundabout Engineering, page 36 and 37
- [2] NCHRP 672, Roundabouts: An Informational Guide-Second Edition

FDM 11-26-35 Signing and Pavement Marking

[February 25, 2011](#)

35.1 Signing

The overall concept for roundabout signing is similar to general intersection signing. Proper regulatory control, advance warning, and directional guidance are required to provide positive guidance to roadway users. Locate signs where roadway users can easily see them when they need the information in advance of the condition. Sign location should be checked so they are not in conflict with vehicle turning movements, or the swept path of vehicles with a long overhang, or vehicle navigation on the OSOW Freight Network. Signs should never obscure pedestrians, motorcyclists or bicyclists. Signing needs differ for urban and rural applications and for different categories of roundabouts. On connecting highways coordinate sign selection with the Region Traffic Section and local agency to maintain consistency on the facility.

The signing and marking can get complex on roundabout projects. To assist project managers and contractors, the designer should use a minimum of 40 scale drawings for signing and marking plan sheets.

The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), the Wisconsin Manual on Uniform Traffic Control Devices, Wisconsin DOT Traffic Guidelines Manual and appropriate sign plate details govern the design and placement of signs. To the extent possible, this text follows the principles outlined in the 2009 MUTCD and the Wisconsin MUTCD supplement to the 2009 MUTCD.

35.1.1 Regulatory Signs

A number of regulatory signs are appropriate for roundabouts and are described below.

1. Install a YIELD sign (R1-2) on both the left (in splitter island) and the right side of all approaches, single lane and multi-lane entrances, to the roundabout. During the first six months of operation of the roundabout, install 18" x 18" orange flags on top of the YIELD signs to emphasize the yield movement. Install a ONE WAY sign, R6-2R, under the left side yield sign on all approaches, single and multi-lane entrances, to the roundabout to establish the direction of traffic flow within the roundabout. Install a TO TRAFFIC FROM LEFT sign, R1-54, under the right side yield sign on all approaches, single and multi-lane entrances, to the roundabout to reinforce the yielding required at a roundabout.
2. Install a ONE WAY sign, R6-1R, in the central island opposite each entrance and mounted above the chevron sign (R6-4b) to emphasize the direction of travel within the circulatory roadway.
3. Install a KEEP RIGHT sign (R4-7) at the nose of raised curb splitter islands. The mounting height of the R4-7 ranges from 5-feet to 7-feet to the bottom of the sign. In urban areas where pedestrians or bicyclists are expected to use the crosswalk it is recommended to use the 7-foot mounting. The Down Arrow, W12-1R, may be used but is less desirable for consistency and driver expectancy but may be mounted 2-feet to the bottom of the sign. Attention should be given to the location of the KEEP RIGHT sign and light poles on the right side to ensure that conflicts do not occur with larger width vehicles. This is especially critical with single lane entry roundabouts.
4. A chevron sign (series of 4 chevrons, R6-4b) shall be used in the central island opposite the entrances in combination with the ONE WAY sign (R6-1R). The mounting height to the bottom of the Chevron sign is 48-inches above the curb & gutter flange that is located between the circulatory roadway and the truck apron [2A.18 MUTCD Wisconsin Supplement]. Specify the four (4) foot mounting height in the Miscellaneous Quantities.

Lane-use signs such as the R3-8 sign are not used for single-lane entries. For multi-lane entries operational reasons will dictate where the R3-8 sign is used.

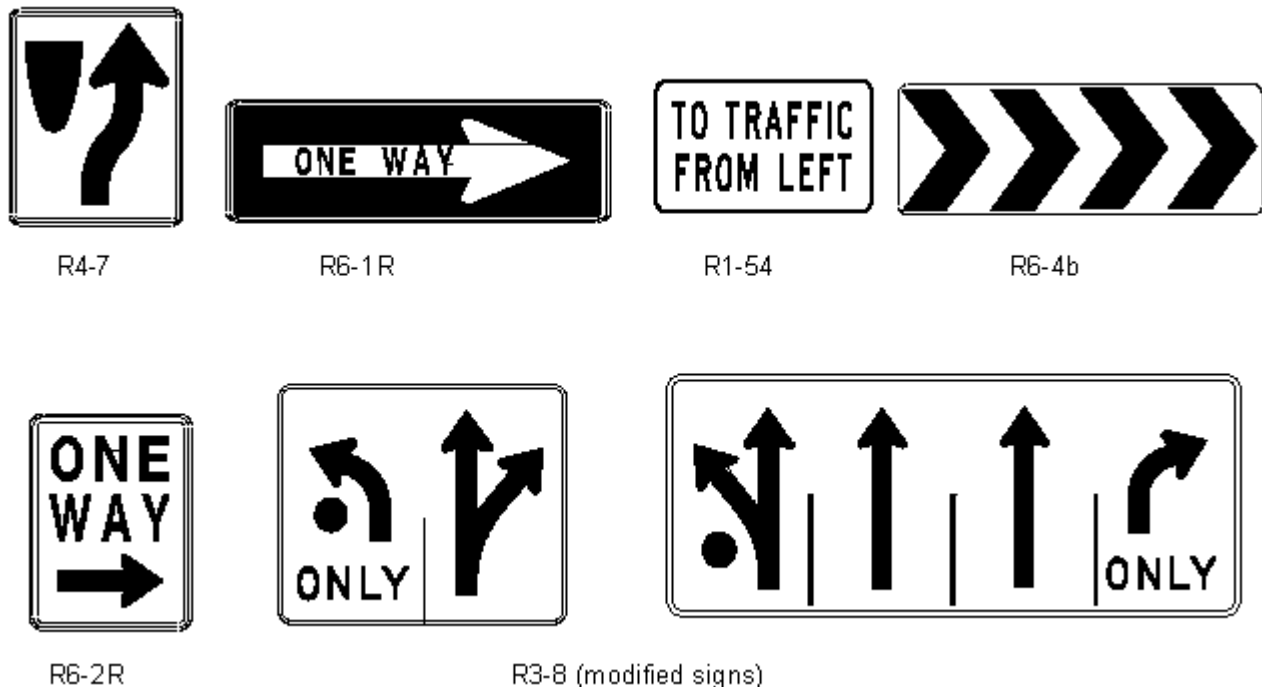


Figure 35.1. Regulatory Signs

* The R3-8 sign is modified to show the placement of a dot under the left arrow, which graphically helps depict the presence of a roundabout. Use the dot under the left arrow, only for the left most lane.

35.1.2 Warning Signs

A number of warning signs are appropriate for roundabouts and are described below. The amount of warning a motorist needs is related to site-specific intersection conditions and the vehicular speeds on approach roadways. The applicable sections of the MUTCD govern the specific placement of warning signs.

1. Install a circular intersection sign ("chasing arrows", W2-6) on each approach in advance of the

roundabout. Below the W2-6 sign, install ROUNDABOUT AHEAD educational sign, W2-6P, and below the W2-6P sign, install an advisory speed plate (W13-1). The speed given on the advisory speed plate should be no greater than the design speed of the circulatory roadway. Advisory speeds are posted in multiples of 5 mph. For conventional highways with posted approach speeds of 45 mph or greater or 3 or more approach lanes, use size 3 W2-6, W2-6P and W13-1 signs and double up the placement of the W2-6, W2-6P and W13-1 signs. For expressways, use size 4 W2-6, W2-6P and W13-1 signs and double up the placement of the W2-6, W2-6P and W13-1 signs. Coordinate with the Region Traffic Section on the proper sign sizes and type of roadway (conventional highway or expressway). For closely spaced roundabouts, these signs may be omitted, see Section 1.6 below for guidance as to when these signs may be omitted.

2. Use a YIELD AHEAD sign (W3-2) on each approach to a roundabout if the approach speed is 45 mph or greater. If the approach speed is less than 45 mph, the YIELD AHEAD (W3-2) would only be needed if the yield sign is not readily visible for a sufficient distance per [Table 35.1](#) below (Minimum Visibility Distance). For closely spaced roundabouts, this sign may also be omitted, see Section 1.6 below for guidance as to when these signs should be omitted.
3. The usage of the pedestrian crossing sign assembly is optional per the 2009 MUTCD. The designer is encouraged to coordinate the usage of pedestrian crossing signs with the Region Traffic Section. If the pedestrian crossing sign assembly is used, the pedestrian ahead sign assembly is recommended if the visibility of the pedestrian crossing sign assembly is poor or if the approach speed is 45 mph or higher. If there is a school crossing at the roundabout, the school warning sign assembly with arrow (S1-1 and WF16-7L) is required at the crosswalk location. In addition, install the school warning sign, AHEAD plaque and FINES HIGHER plaque (S1-1, WF16-9P and R2-6P) in advance of the school crosswalk assembly. Install the pedestrian crossing sign (W11-2 and W16-7L) or school crossing sign assembly (S1-1 and WF16-7L) just in front of the crosswalk for approaching traffic and at the exit locations just in front of the crosswalk for approaching traffic also. Generally, rural roundabouts will not have pedestrian accommodations. However, if pedestrians are anticipated then the pedestrian signs referred to above are needed. School crossing signs are required if there are any school pedestrians. If the crosswalk at a roundabout is not considered to be part of the intersection and is instead considered a marked mid-block crossing, pedestrian crossing signs are required.
4. A bicycle sign may be needed to designate the exit to the bike path (D11-1 and M7-1, Federal sign plate).

Locate pedestrian crossing signs in such a way to not obstruct the approaching driver's view of the YIELD sign or pedestrians standing at the crosswalk.

Flashing beacons may be used above some warning signs as a long-term awareness technique for areas with approach speeds of 45 mph or higher.

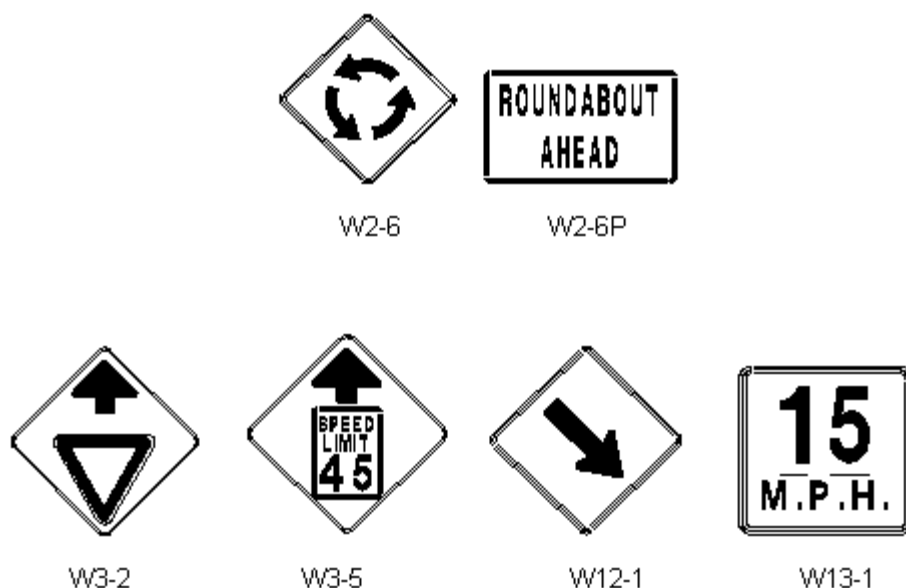


Figure 35.2. Warning Signs

35.1.3 Guide Signs

Guide signs provide drivers with needed navigational information. They are particularly needed at roundabouts since circular travel may disorient unfamiliar drivers. Overhead guide signs should be considered at multi-lane roundabout approaches to guide motorists into the proper travel lane in order to navigate the roundabout properly and help avoid lane changing within the roundabout. A number of guide signs are appropriate for roundabouts and are described below.

35.1.3.1 Intersection Destination/Direction style signs

Use intersection destination/direction style signs in all single lane approach roundabouts for rural locations and in urban/suburban areas where space allows and is appropriate. The diagrammatic style guide sign is preferred over the text style sign (D1 series sign); examples of both are shown. The circular shape in a diagrammatic guide sign provides an important visual cue to all users of the roundabout. Diagrammatic guide signs are preferred because they reinforce the form and shape of the approaching intersection and make it clear to the driver how they are expected to navigate the intersection. If lack of terrace space or longitudinal location spacing are issues, use a text style sign or overhead diagrammatic guide sign.

Use 4 ½" lower case / 6" upper case letters with 18" Interstate, U.S. and State route shields and 15" County route shields for ground mounted signs in urban and rural areas where posted speed is less than 45 mph, and 2 or less approach lanes. Use 6" lower case / 8" upper case letters with 24" Interstate, U.S. and State route shields and 20" County route shields for signs in urban and rural areas if the signs are overhead, posted speeds are 45 mph or greater or there are 3 or more approach lanes. In general, the lettering height rule of thumb is to provide approximately 1-inch in letter height for each 40-foot of distance from the sign. All capital letters are harder to read than the first letter capitalized with the following letters small case. Cardinal directions shall be all capital letters with the first letter slightly larger.

The arrow direction conventions for the text signs follow the same convention as that for conventional intersections as shown in the 2009 MUTCD, Section 2D.37. The ahead destination is on top, the left destination in the middle and the right destination on the bottom. The curved-stem arrow (D1-1d signs) shown in the 2009 MUTCD, Section 2D.38 are not used.

Occasionally, Specific Information Signs (SIS – GAS, FOOD, LODGING, CAMPING or ATTRACTIONS) may need to be included on roundabout approaches. The arrow direction convention and placement of SIS signs follows the 2009 MUTCD, Section 2J.09.

Sample dimensioned details on the designs of diagrammatic signs, including the arrow and shaft dimensions are shown on the Bureau of Traffic Operations A11-12 sign plate.

There are examples of each shown below. Intersection destination signs may not be necessary at local street roundabouts or in urban settings where there are no significant destinations and the majority of users are familiar with the site.

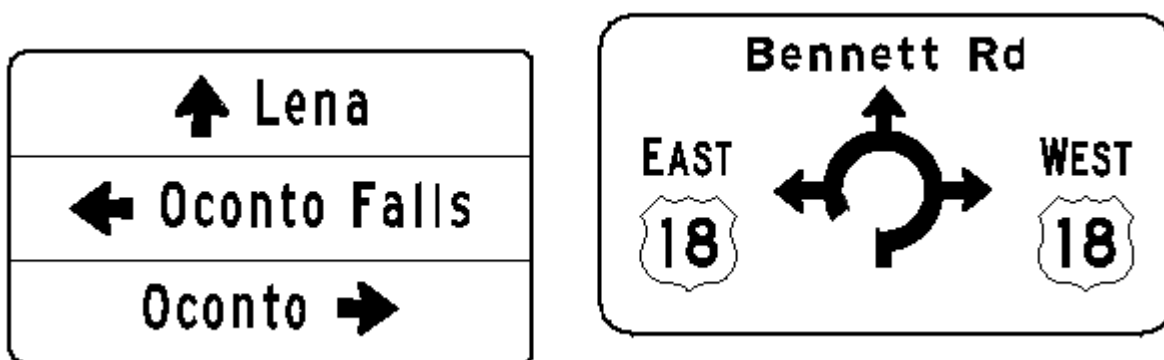


Figure 35.3. Destination Signs

35.1.3.2 Overhead Lane Guide Signs

In general, overhead lane guide signs are encouraged at roundabouts with multiple approach lanes. By giving destination guidance to the motorist in advance, the motorist will be able to be in the correct lane at the roundabout approach and be discouraged from making a lane change within the roundabout. Qualifying criteria for overhead lane guide signs would include two or more approach lanes, higher vehicle ADT's, lane splits approaching roundabouts, dual turn lanes, if the major route is turning, closely spaced roundabouts, narrow terrace widths, unfamiliarity of drivers, and lane drops within the roundabout. Since these are lane use guide

signs, they would have an up arrow. A sign is placed over each travel lane (see urban roundabout layout example in [Attachment 35.3](#)) and the arrow is typically placed over the center of the lane. Coordinate sign designs with the Region Traffic Operations section and the Bureau of Traffic Operations Traffic Design unit. If overhead guide signs are used on an approach, then the circular diagrammatic guide sign is normally not needed. The circular diagrammatic guide sign is good for showing destinations and directions, however it does not depict proper lane assignments like the overhead lane guide signs do.

Use 8" lower case / 10.67" upper case letters with 24" Interstate, U.S. and State route shields and 20" County route shields for all overhead signs. For situations with overhead structure loading limitations, 6" lower case / 8" upper case letters with 18" Interstate, U.S. and State route shields and 15" County route shields may be used. Use a dot with the left arrow to designate the roundabout.

Sample details of overhead lane guide signs are shown below. Additional dimensioned details on the designs of diagrammatic signs, including the arrow and shaft dimensions are shown on the Bureau of Highway Operations A11-13 sign plate.

Generally use overhead sign supports, not sign bridge trusses. See [FDM 11-55-20](#) for overhead sign support design guidance.

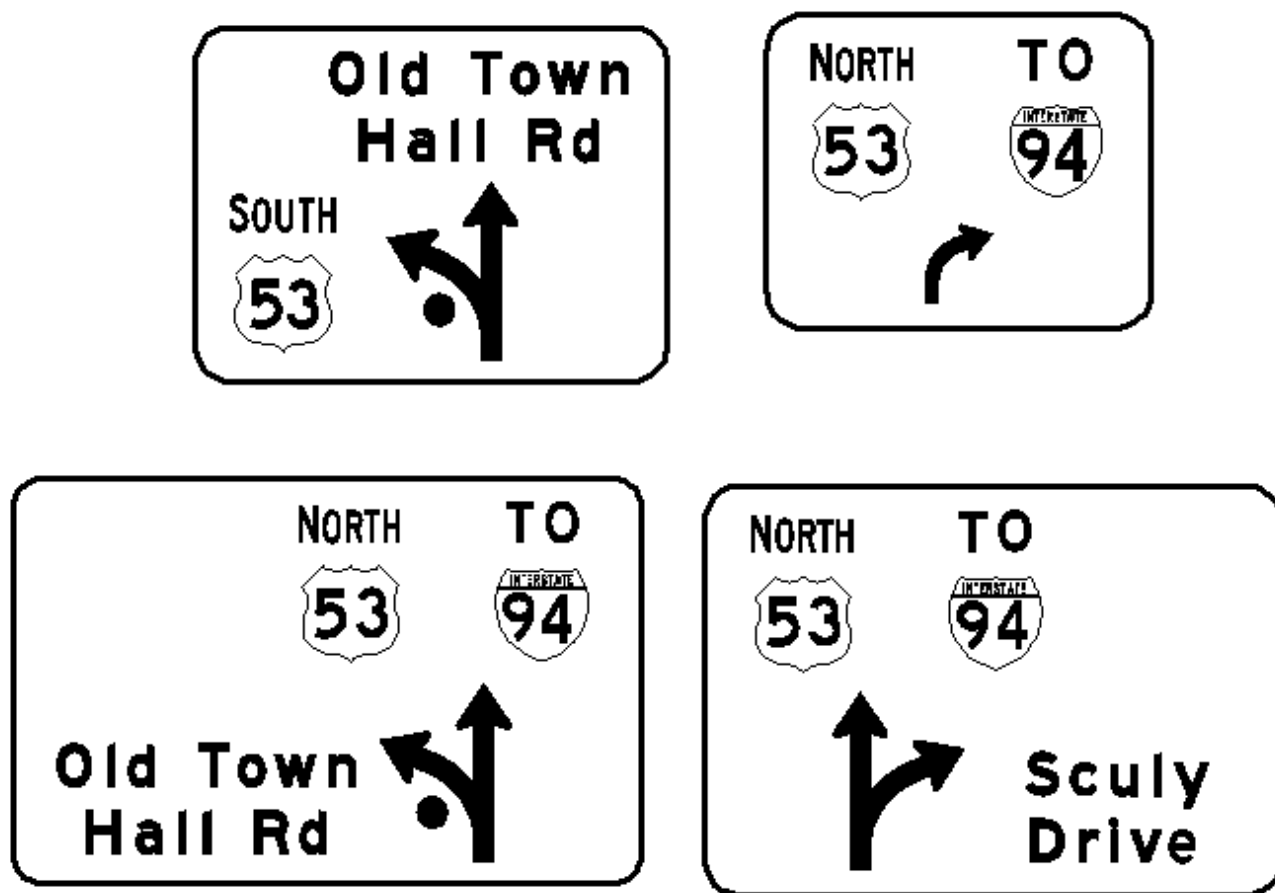


Figure 35.4. Side-by-Side Overhead Lane Guide Signs

35.1.3.3 Exit Guide Signs – In Splitter Island

Exit guide signs reduce the potential for disorientation. Use them to designate the destinations of each exit from the roundabout. These signs are conventional intersection direction signs (D1 series signs). Exit guide signs with route shields should have the shield incorporated into the sign with cardinal direction and arrow. The arrow is slanted up and to the right. At freeway ramp situations utilize the route continuation with exit on the exit guide sign. Letter heights for signs are 4 ½" lower case / 6" upper case with 12" route shields. Signs are placed in the splitter island facing the circulating traffic. The mounting height is to be a minimum of 60-inches from the ground to the bottom of the sign. Specify the revised mounting height in the special provisions.

Sample details of exit guide signs are shown below. Additional dimensioned details on the designs of the exit guide signs are shown on the Bureau of Traffic Operations A11-14 sign plate.

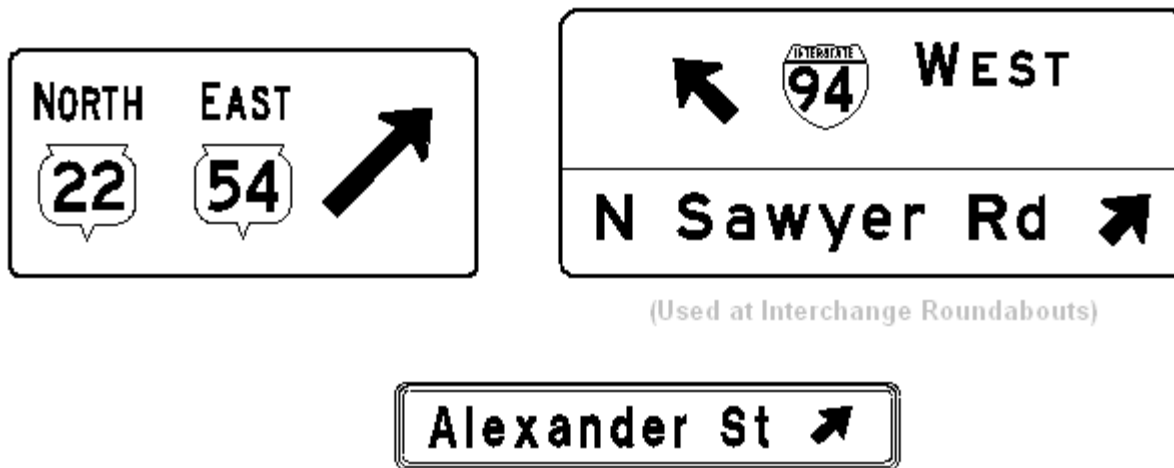


Figure 35.5. Exit Signs

35.1.3.4 Junction Assemblies

As with traditional intersections, consider using junction assembly consisting of either a “JCT” (M2-1) auxiliary sign with the appropriate route markers or a junction (J1-1) assembly in advance of the roundabout.

35.1.3.5 Route Confirmation Signs

For roundabouts involving the intersection of one or more numbered routes, install confirmation assemblies (J4's) directly after the roundabout exit to reassure drivers that they have selected the correct exit at the roundabout. Locate confirmation assemblies no more than 500 feet beyond the intersection in urban or rural areas. If possible, locate the assembly's close enough to the intersection so drivers in the circulatory roadway can see them.

35.1.4 Urban Signing Considerations

Urban intersections tend to exhibit lower speeds. Consequently, the designer can, on a case-specific basis, consider using fewer and smaller signs in urban settings than in rural settings. However, include some indication of street names in the form of exit guide signs or standard street name signs. Also review proposed signing to ensure that sign clutter will not reduce its effectiveness. Avoid sign clutter by prioritizing signing and eliminating or relocating lower priority signs. A sample signing plan for an urban application is shown in [Attachment 35.3](#).

35.1.5 Rural and Suburban Signing Considerations

Route guidance emphasizes destinations and numbered routes rather than street names. The exit guide sign needs to be visible (but discrete) from within the roundabout and much smaller than the typical rural shields and lettering size. Six inch upper case and 4-1/2 inch lower case lettering height is the maximum needed. A sample signing plan for a rural application is shown in [Attachment 35.4](#).

35.1.6 Closely Spaced Multiple Roundabouts

Often times multiple roundabouts may be installed in close proximity to each other (roundabouts ¼ mile apart or less). This can often happen at interchange ramp terminals and roundabouts beyond ramp terminals at frontage roads. Multiple roundabouts in close proximity to each other can cause signing challenges due to longitudinal space constraints between the roundabouts. As a result, some signing may be eliminated between the roundabouts. Visibility distance is based on stopping sight distance of vehicles. The roundabout warning assembly signs (W2-6, W2-6P and W13-1) and YIELD AHEAD (W3-2) may be eliminated between roundabouts if the visibility distance between the roundabouts exceed the minimum visibility distance shown in [Table 35.1](#). Other signs may be eliminated with consultation with the Region Traffic Section. The roundabout warning assembly signs and YIELD AHEAD would continue to be placed at the approaches to the first roundabouts in the series.

Table 35.1 Minimum Visibility Distance*

Posted or 85 th Percentile Speed	Minimum Visibility Distance
25 mph	280 ft
30 mph	335 ft
35 mph	390 ft
40 mph	445 ft
45 mph	500 ft
50 mph	555 ft
55 mph	610 ft

* Minimum Visibility Distances are from Section 2C.36 of the Wisconsin Supplement to the 2009 MUTCD

35.1.7 Roundabouts in Close Proximity to Railroad Crossings

Railroad crossings in close proximity to roundabouts can present additional signing challenges due to safety concerns involving railroad crossings and the installations of additional signs in spaces already containing a lot of signs. Because each railroad crossing is unique, roundabout designers need to contact the Bureau of Traffic Operations Traffic Design unit and the appropriate Region Traffic Operations section for the proper signing and marking layout if the railroad crossing is 750 feet or less from the roundabout.

35.1.8 Wrong Way Movements in Roundabouts

There is a potential for wrong way movements at roundabouts, especially roundabouts that are new in an area. The typical signing applications include the usage of a chevron sign (series of 4 chevrons, W1-8a) in the central island with a One Way sign (R6-1R sign) mounted above it. In addition, a One Way sign is mounted below the left side YIELD sign. If wrong way movement problems persist, there are some signing options that can be employed:

- Oversize ONE WAY sign in the central island, above the chevron sign.
- Do Not Enter Signs mounted in the circular island to face potential wrong way traffic.
- R5-1 (DO NOT ENTER) sign is required for roundabouts at ramps per TGM policy 2-15-12 mounted on the outside radius of roundabout as shown in the detail in 2-15-12.

35.1.9 Short Term Awareness Techniques

Some of the following bullet items are listed as short-term awareness techniques and others are mitigation considerations after field problems have been identified. In either situation contact the Region Traffic Engineer for guidance. Do not expect traffic control devices to accomplish what the geometric design cannot.

- Provide portable changeable message signs.
- Install orange flags on top of the YIELD signs during the first six months of operation.

35.1.10 Maintenance of Signs

For roundabouts on the State System with county highway approaches and/or local road approaches, it is recommended that early in the design process, a Maintenance Agreement be developed. By having the Maintenance Agreement developed early in the design process, the county or local unit of government will clearly have knowledge of what they are to maintain.

Some particular items that *should* be included in the Maintenance Agreement would include:

- Specific signs that WisDOT would maintain and what the locals/county would maintain. This would also include signposts.
- Specific overhead sign supports (if any), that WisDOT would maintain and what the locals would maintain.
- Recommended inspection frequencies for overhead sign supports that the locals would maintain.

Further guidance on the maintenance of signs for roundabouts is included in the Traffic Guidelines Manual, policy 2-15-52.

35.1.11 Signing Installation for Oversize / Overweight Vehicle Routes

Careful attention must be given to signs that are installed for roundabouts on oversize / overweight vehicle routes. Periodically signs and posts may have to be temporarily removed to accommodate the vehicles to pass through the roundabout and turn properly.

For roundabouts on oversize / overweight routes, install tubular steel sign post assemblies, or a comparable system (approved by the Project Engineer) for the following signs:

1. Left Side Yield sign (R1-2 sign) / ONE WAY sign (R6-2R sign).
2. Right Side Yield sign (R1-2 sign) / TO TRAFFIC FROM LEFT (R1-54 sign).
3. Exit Guide signs (D1 series signs) in the splitter islands.
4. Pedestrian crossing signs (W11-2 signs) at the intersection crosswalks.
5. Roundabout chevron bank (R6-4B sign) and ONE WAY (R6-1R sign) in the circular island.
6. Any signs located on the median island separating a right turn lane from the through lane(s).
7. Any additional signs on the outer portion of the roundabout circle.

Install tubular steel sign post assemblies in accordance with [standard spec 634.3.2](#). To help prevent bending of the anchor tube and potential puncturing of vehicle tires, place the top of the 2 ¼" x 2 ¼" anchor level with the top of the 12" diameter PVC box-out (which is at ground level). The box-out is typically filled with gravel or dirt which will require about 2" of it to be removed in order to access the corner bolt when removing/reinstalling the post. The designer will need to ensure that notes are placed on the permanent signing plan to notify contractors of the required height of the top of the anchor system.

35.2 Pavement Marking

Typical pavement marking for roundabouts consists of delineating the entries and marking the circulatory roadway on multi-lane roundabouts. Single lane roundabouts need no lane arrows or circulatory roadway pavement marking, except for edge line marking. Bike lane marking within the circulatory roadway is not permitted on any roundabouts. Pavement marking is needed on multi-lane roundabouts. The more complex the roundabout and the higher the volume, the greater is the need for proper pavement marking. Pavement marking must be closely evaluated when designing a roundabout. Pavement marking is part of a "whole system" to consider, meaning that various design concepts from geometric design, to signing, and pavement marking should complement each other.

The MUTCD provides pavement marking guidelines and standards. Applicable local standards may also govern the design and placement of pavement marking as long as they do not conflict with the MUTCD and WisDOT policies. Roundabouts present a number of new pavement marking issues that are not addressed in the 2003 MUTCD or the FHWA Roundabout Guide. For this reason, new pavement marking concepts and widths as well as existing pavement markings are shown in this guidance. On connecting highways coordinate pavement marking with the Region Traffic Section and the local agency to maintain consistency on the facility.

35.2.1 Approach and Entry Pavement Markings

Approach and entry pavement markings consist of channelization marking, dotted edge line extension marking, yield line and symbol markings. Consider high durability markings on the approaches and entries.

35.2.1.1 Approach marking

Pavement marking adjacent to the splitter island shall be 4-inch yellow along the left edge of entrance and exit areas for single and multi-lane roundabouts. Right edgeline, if used, is 4-inch white. It is important to separate the lanes on multi-lane entrances. To do this it may be appropriate to provide either 4-inch or 8-inch white channelizing line just prior to the yield point to assist in lane utilization. When space is allowed, it is optional to add a 4-inch or 8-inch white line with equal length line and gap, prior to the solid 4-inch or 8-inch channelizing line. See additional pavement marking guidance in the TGM 3-2-24.

Provide minimum 6-inch wide crosswalk pavement marking where pedestrian traffic is expected. Crosswalk marking patterns using longitudinal or diagonal lines as described in TGM 3-2-17 are options.

The edgeline adjacent to the splitter island along the right edge of the circulatory roadway is 8-inch white. The dotted edgeline extension used to demarcate the entry approach from the circulatory roadway is 18-inches wide for all roundabout, with a 2 ft line, 2 ft gap and located along the inscribed circle. Set the dotted edge line extension slightly back from the circulating roadway to prevent circulating traffic from scuffing the markings. Do not place pavement marking to demarcate the exit from the circulatory roadway.

Single lane entrances have no lane markings at the entrance. Multi-lane entries require lane assignment, which is critical to provide maximum capacity and safety. The approach lane markings are based on the entry volume and projected turning movements.

For approach signs and pavement marking arrows use a dot with the left arrow or combined left-through arrow only on the left most lane. This dot with the arrow has the potential to reduce confusion and wrong-way

movements in the circulatory roadway, and is preferred over the fish-hook arrow used at some locations in Wisconsin and other states. See [Figure 35.6](#) for typical detail of a dot with left pavement marking arrow.

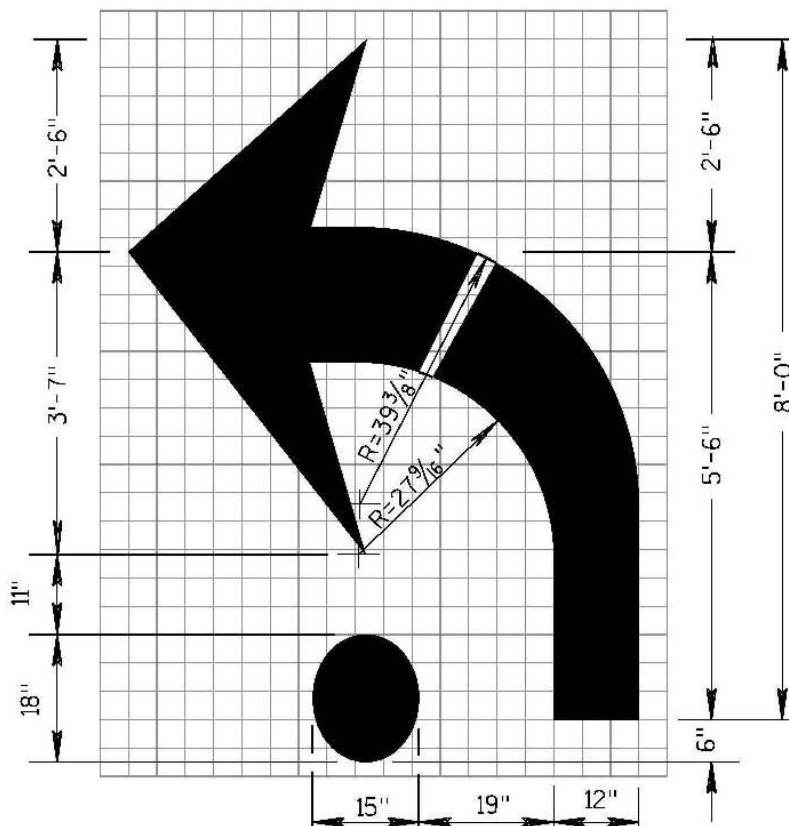


Figure 35.6. Left Turn Arrow with dot

Assume that one leg of an approach on a 4-leg roundabout flares to two lanes. The flare must be developed uniformly and avoid any sharp curb break as the flare starts. When the flare widens from a single lane to 19 ft (centerline or inside curb face to outside curb face), begin the pavement marking to form two lanes as shown in [Figure 35.7](#) (a). The skip-dash or solid white lane line pavement marking leading up the yield point divides the approaching traffic into two lanes.

In addition to approach lane markings, appropriate lane arrows encourage balanced lane use, which improves capacity and safety. Left turn arrows are very important on multi-lane approaches. Traffic often has a bias towards the right-most lane. Lane arrows either encourage this bias, or can encourage better lane utilization. Lane arrows can be complex with subtle problems that can reduce capacity and cause crashes, so great care and understanding is needed. [Figure 35.7](#) (b) shows the use of pavement marking arrows that assist lane utilization in advance of the roundabout yield point. Lane utilization becomes even more important at 3- and 4-lane entries. The beginning of the skip dash pavement marking is intended as a visual cue to drivers to select an appropriate lane for entering the roundabout. It should not be considered lane width marking because the flare is widening at this point.

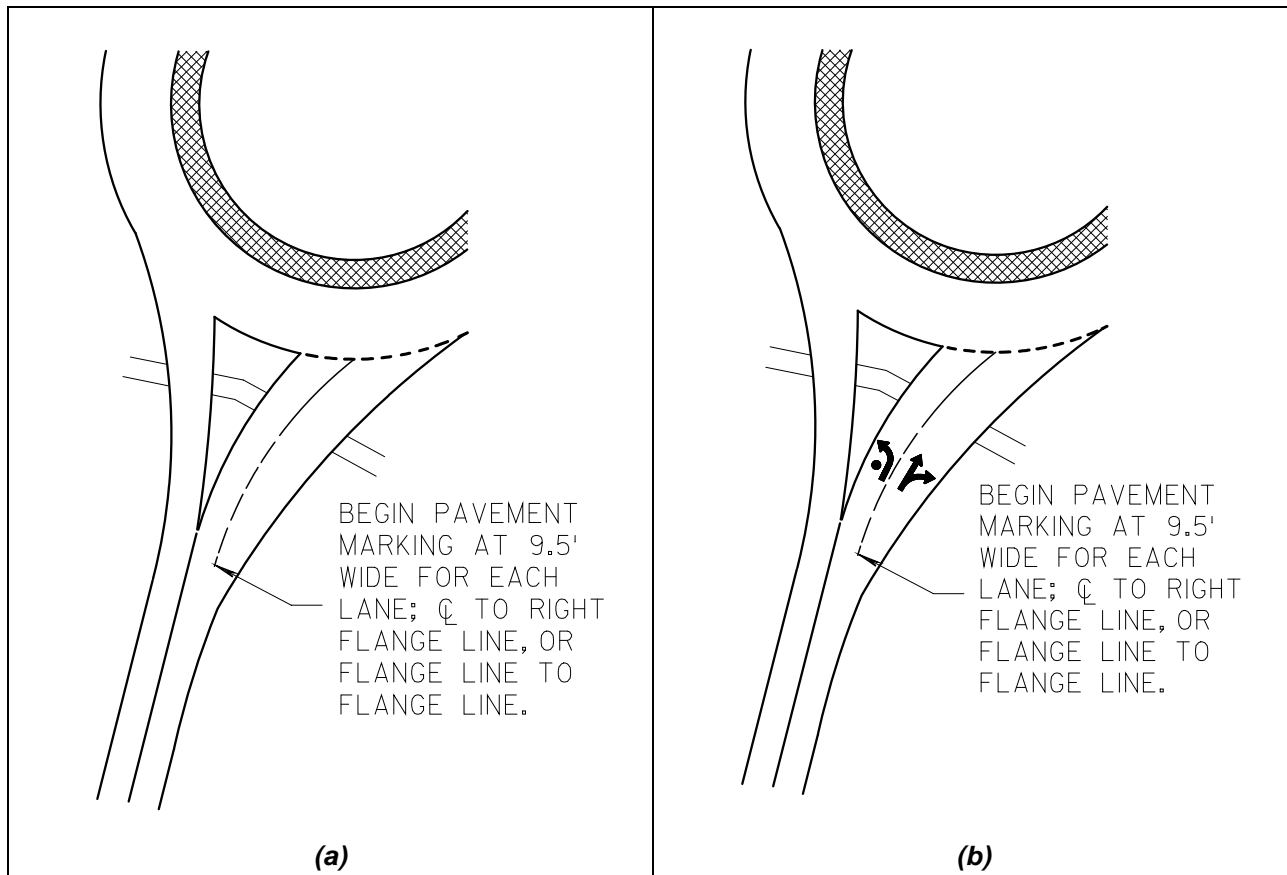


Figure 35.7. Pavement Marking

Shown in [Attachment 35.1](#) is the similarity of dual left turn lane marking between a signalized intersection and a roundabout. The approach arrows shown are only an example. Final arrow type depends on internal roundabout lane functions.

35.2.1.2 Entrance Emphasis Pavement Marking

Pavement word or symbol markings to supplement the signing and yield point marking may be desirable, consult with the Region Traffic Engineer for further guidance. These markings should conform to the standards given in 2003 MUTCD, Section 3B.19. Install chevrons 12-inches wide on 10-foot centers as shown in the TGM 3-2-24 if the gore area near the splitter island adjacent to the circulatory roadway is fairly large.

If higher emphasis is needed, it may be appropriate to use YIELD words in each approach lane prior to the dotted edge line extension. TGM 3-2-24 shows pavement markings for a typical roundabout entrance and exit.

35.2.2 Circulatory Roadway Pavement Marking

Circulatory pavement markings apply only to roundabouts with multi-lane entrances. These markings consist of arrows, spiral striping, and, on rare occasions, skip-dash channelizing lines. Never use concentric circle pavement marking on the circulatory roadway. All movements must be traced through the roundabout to avoid conflicts in the same peak and to avoid conflicts between peaks. This task is not easy and must be reviewed by an experienced roundabout designer and the Region Traffic Engineer.

Circulatory roadway arrow marking is important to educate US drivers and encourage correct lane usage. Circulatory roadway spiral pavement marking adjacent to the central island requires considerable engineering judgment to design and locate properly. As can be seen in [Attachment 35.2](#) (b)(c), spirals can be used to reduce the circulatory pavement width and direct traffic into the appropriate lane. It is just as important to make sure field layout and pavement marking application on the circulatory pavement is located and positioned correctly. A pavement marking layout detail showing the exact locations is required. Consider wheel tracking when developing the pavement marking layout detail. Consider high durability marking for the dotted edgeline extensions and marking within the circulatory roadway. The spirals may have to be applied with hand application rather than with a truck application. If the designer determines that hand application is required it must be specified in the special provisions. Proper pavement marking within the circulatory roadway will help prevent left turns from the outer lane and thus reduce exit crashes.

[Attachment 35.2](#) shows example pavement marking of various common design types. [Attachment 35.3](#) and [Attachment 35.4](#) show a sample signing plan for an urban and a rural roundabout respectively. These are examples only and specific marking and signing for each roundabout may be different.

LIST OF ATTACHMENTS

Attachment 35.1	Double Left Turn at Signal and Roundabout
Attachment 35.2	Example Pavement Marking for Typical Designs
Attachment 35.3	Sample Signing Plan for an Urban Roundabout
Attachment 35.4	Sample Signing Plan for a Rural Roundabout

FDM 11-26-40 Illumination, Landscaping, and Maintenance

[February 25, 2011](#)

40.1 Illumination

A driver must be able to perceive the general layout and operation of an intersection in time to make appropriate maneuvers. Whenever a facility is designed for use by several user groups (motor vehicles, pedestrians and bicycles or mopeds), the roundabout must be illuminated. Therefore, adequate lighting needs to be at all roundabouts. Additional illumination guidance is found in TGM 11-11-1.

When state and/or federal funds are used they should pay 100 percent of the initial installation cost for non-decorative lighting fixtures and materials. The ownership type will determine whether the equipment maintenance and the electricity use is paid by the local unit of government or the State. When the lighting is on a local highway system or a connecting highway the local unit of government is responsible for the cost associated with maintenance of the equipment and the electricity use. For roundabouts on state highways, the lighting equipment maintenance and electricity may be paid by the State.

40.1.1 Need for Illumination

The need for illumination varies depending on the location of the roundabout.

1. Urban Conditions - Illuminate urban roundabouts if all or most of the approaches are illuminated and where necessary to improve the visibility of pedestrians and bicyclists. If the designer's goal is to emphasize the role of this facility as a transition speed zone, illumination becomes an important asset.
2. Suburban Conditions - In general, illumination is beneficial and needs to be considered for all suburban roundabouts. Illumination is particularly recommended for safety reasons when any of the following conditions are present.
 - One or more approaches are illuminated.
 - Competing non-roadway illumination in the vicinity can distract the driver's attention (i.e. highly illuminated parking lots, car lots or filling stations).
 - Heavy nighttime traffic is anticipated.
 - Pedestrian traffic is anticipated (approaches have sidewalks).

Provide continuity of illumination level between approaches and the roundabout itself to avoid distracting drivers and to minimize the need for the driver's eye to adjust to changing lighting levels.

3. Rural Conditions - Illumination should be installed at rural roundabouts. Use reflective pavement marking and retroreflective signs (including chevrons supplementing the ONE-WAY signs) regardless of whether illumination is provided. Reflectivity shall conform to the Standard Specifications.

Illuminate the approach nose of the splitter island and any raised channelization or curbing. In general, provide a gradual illumination transition zone of approximately 250 feet beyond the final trajectory changes at each exit. This helps drivers adjust their vision back into the dark environment of the exiting roadway, which takes approximately 1 to 2 seconds. In addition, avoid short-distance dark areas between two consecutive illuminated areas.

40.1.2 Standards and Recommended Practices

Category I

Illumination of new or temporary roundabouts where existing adjacent roadways are not illuminated or current illumination of adjacent roadways are below standard.

Generally, the illumination levels of conventional intersections should be approximately equal to the sum of the

illumination levels of the intersecting roadways.

The basic principle behind the lighting of roundabouts in urban and suburban areas is that the amount of light on the intersection should be proportional to the light provided on the intersecting streets and equal to the sum of the values used for each separate street.

WisDOT recommends a simplified approach to street illumination, which is to design illumination for asphaltic pavement surface conditions. Illumination recommendations for concrete pavement will generally not be considered on the state trunk highway system. For roundabouts, WisDOT will use the information presented in [Table 40.1](#) and [Table 40.2](#) to determine the design level of illumination (computed using [Table 40.3](#)) rather than the existing light levels of the streets that approach the roundabout.

Design the roundabout to have the illumination levels given in [Table 40.1](#). This would result in illumination levels at the roundabout ranging from 8 lux (0.7 fc) for roundabouts at the intersection of two local streets with low pedestrian traffic volume (two intersecting local streets each having an illumination level of 4 lux, the resulting sum is 8 lux), to 34 lux (3.4 fc) for roundabouts at the intersection of two major streets with high pedestrian traffic volume. [Table 40.2](#) provides a description of roadway classification with related volumes and pedestrian conflict area classification with related volumes. Complete the form in [Table 40.3](#) to determine the intersection illumination level.

Table 40.1 Illuminance Levels at Roundabouts and Other Intersections

Recommended Illuminance for Intersections				
Roadway Classification (Street A/Street B)	Average Maintained Illuminance at Pavement ¹			Uniformity Ratio (E _{avg} /E _{min}) ²
	Pedestrian/Area Classification			
	High lux (fc)	Medium lux (fc)	Low lux (fc)	
Major/Major	34.0 (3.2)	26.0 (2.4)	18.0 (1.7)	3.0
Major/Collector	29.0 (2.7)	22.0 (2.1)	15.0 (1.4)	3.0
Major/Local	26.0 (2.4)	20.0 (1.9)	13.0 (1.2)	3.0
Collector/Collector	24.0 (2.2)	18.0 (1.7)	12.0 (1.1)	4.0
Collector/Local	21.0 (2.0)	16.0 (1.5)	10.0 (0.9)	4.0
Local/Local	18.0 (1.7)	14.0 (1.3)	8.0 (0.7)	6.0

¹ fc = foot candles (conversion factor from lux to foot candles is 10.67.)

fc has been rounded to the nearest tenth

² E_{avg} = Horizontal Illuminance, E_{min} = Vertical Illuminance

Source: ANSI / IESNA RP-8-00 Table 9

Values in [Table 40.1](#) assume typical asphalt roadway surface. WisDOT will not use different pavement classifications to determine illumination levels.

Table 40.2 ANSI/IESNA RP-8-00 Guidance for Roadway and Pedestrian/Area Classification For Purposes of Determining Intersection Illumination Levels

Roadway Classification	Description	Existing Daily Vehicular Traffic Volumes ¹
Major	That part of the roadway system that serves as the principal network for through-traffic flow. The routes connect areas of principal traffic generation and important rural roadways leaving the city. Also often known as “arterials,” thoroughfares,” or “preferentials.”	Over 3,500 ADT
Collector	Roadways servicing traffic between major and local streets. These are streets used mainly for traffic movements within residential, commercial, and industrial areas. They do not handle long, through trips.	1,500 to 3,500 ADT
Local	Local streets are used primarily for direct access to residential, commercial, industrial, or other abutting property.	100 to 1,500 ADT
Pedestrian Conflict Area Classification	Description	Guidance on Existing Pedestrian Traffic Volumes ²
High	Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas, near theaters, concert halls, stadiums, and transit terminals.	Over 100 pedestrians/hour
Medium	Areas where lesser numbers of pedestrians use the streets at night. Typical are downtown office areas blocks with libraries, apartments, neighborhood shopping, industrial, older city areas, and streets with transit lines.	11 to 100 pedestrians/hour
Low	Areas with very low volumes of night pedestrian usage. These can occur in any of the cited roadway classifications but may be typified by suburban single-family streets, very low-density residential developments and rural or semi-rural areas.	10 or fewer pedestrians/hour

¹ For purposes of intersection lighting levels only

² Pedestrian volumes during the average annual first hour of darkness (typically 6:00 pm-7:00 pm) representing the total number of pedestrians walking on both sides of the street plus those crossing the street at non-intersection locations in a typical block or 200 m (656 ft) section. RP-8-00 clearly specifies that the pedestrian volume thresholds presented here are a local option and should not be construed as a fixed warrant.

Category II

Illumination of new or temporary roundabouts where existing adjacent roadways are illuminated and meet the AASHTO Informational Guide to Roadway Lighting (1984, Table 3 values).

The roundabout illumination level should be equal to the sum of the illumination values used/available for each individual street. For example if Street A has existing illumination level x and Street B has an existing illumination level of y , then illuminate the roundabout at a level of $x+y$.

If the existing roadways do not meet the AASHTO roadway lighting levels, then the lighting criteria used is specified using category I.

Table 40.3 Roundabout Illumination Determination Form

Intersection Information	
Location: _____	
Street Name A: _____	ADT: _____
Street Name B: _____	ADT: _____
Pedestrian Count: _____ (See Table 40.2)	
Roadway Classification	
Street A Classification: _____ (Major, Collector, Local from Table 40.2)	
Street B Classification: _____ (Major, Collector, Local from Table 40.2)	
Pedestrian Classification: _____ (High, Medium, Low from Table 40.2)	
Determine Illumination Level	
Use information from Roadway Classification above and go to Table 1 to select appropriate illumination level.	
Illumination Level: _____ Uniformity Ratio: _____	

40.1.3 General Recommendations

The primary goal of illumination is to avoid surprising drivers by enabling them to see and navigate the geometric features and the deflection of the roundabout and the approach geometry and traffic control. Lighting also facilitates mutual visibility among the various users. To achieve this, the following features are recommended:

- Provide good illumination on the approach nose of the splitter islands, at all conflict areas where traffic is entering the circulating stream, and at all places where the traffic streams separate to exit the roundabout.
- Light the roundabout from the outside in towards the center to improve the visibility of the central island and the visibility of circulating vehicles to vehicles approaching to the roundabout. Avoid lighting from the central island outward since vehicles become shadows against the light, and thus, less visible. If it is desired to illuminate specific objects in the central island, use ground level lighting within the central island that shines upwards towards the objects and away from the nearest roadway. Always put accent lighting on separate electrical disconnects from roadway lighting for the purpose of blackout protection.
- Consider lighting pedestrian crossing and bicycle merging areas.

40.1.4 Light pole position

The position of lighting poles relative to the curbs at a roundabout is governed in part by the speed environment in which the roundabout is located and the potential speeds of errant vehicles that can be reasonably expected.

Providing good pedestrian recognition is an important issue at roundabouts. Crosswalks at roundabouts should typically be lit with the pedestrians in positive contrast. Light poles placed 10 feet to 30 feet before the crosswalk is recommended for this purpose. It should also be noted that poles should be offset 10 feet from the roadway especially for signal lane approaches to allow adequate spacing for farming equipment to safely maneuver the roundabout and is preferred on multi-lane approaches. Providing an offset of 10 feet or more from the curb face allows greater opportunity of passage for OSOW vehicles.

At locations where pedestrian facilities do not exist, consideration should be given to a layout that assumes a future multi-use path will be provided. The layout should take into consideration longitudinal placement as described above as well as lateral offset to avoid major facility relocations when pedestrian and/or bicycle paths are provided in the future.

Avoid placing lighting supports and other poles or hazards within the splitter islands or on the right-hand perimeter just downstream of an exit point. Avoid placing light poles in the central island.

40.2 Landscaping

The goal for State owned and maintained roundabouts is to achieve a landscape design that enhances the safety in the area of the central island and splitter islands with little or no landscape maintenance required over time. Landscape design elements should minimize areas of mulch and the planted vegetation that requires maintenance. When hardscape materials are included in the design they must not appear to be traversable either by motorists or pedestrians.

Landscape elements are vital to the proper operation of a roundabout, and needs to be in place when the roundabout is opened to traffic. The purposes of landscape elements in the roundabout are to:

- Make the central island conspicuous to drivers as they approach the roundabout.
- Clearly indicate to drivers that they cannot pass straight through the intersection. Restrict the ability to view traffic from across the roundabout through mounding of the earth and plantings.
- Require motorist's to focus toward on-coming traffic from the left.
- Discourage pedestrian traffic through the central island.
- Help blind and visually impaired pedestrians locate sidewalks and crosswalks.
- Improve and complement the aesthetics of the area

When designing landscaping for a roundabout it is important to:

- Consider maintenance requirements early in the program stages of development.
- Develop a formal municipal agreement describing the landscaping and maintenance requirements for roundabouts elements early in the scoping process and prior to design of the facility.
- Maintain adequate sight distances
- Avoid obscuring the view to signs
- Minimize fixed objects such as trees, poles, or guard rail.
- Apply the guidance below relative to approach speeds and the permissible use of fixed objects such as trees, poles, non-hazard walls, non-hazard rocks/boulders, or guard rail.

Landscape the central island by mounding the earth and providing planting. Refer to [Figure 40.1](#) for the general layout of the central island. The clear zone and lateral clearance requirements for roundabouts are provided in [FDM 11-26-30](#), Section 5.24. The truck apron is not part of this clear zone distance. The clear zone for the central island is considered to begin at the inside curb adjacent to the central island landscaping.

The combination of the earth mound and plantings in the central island shall provide a visual blocking such that drivers will not be able to see through the roundabout central island. The central island area is considered a low speed environment however errant vehicles occasionally end up in the central island or crossing the central island.

The approach highway speed is an indicator of the probability of an errant vehicle entering the central island. Therefore, when the posted speed on any approaching leg to the roundabout is greater than 30 mph the following items are prohibited within the central island: hazardous material such as concrete, stone, or wood walls or other fixed objects, including trees having a mature diameter greater than 4-inches.

Where the approaching leg to a roundabout has a posted speed of 30 mph or less there may be objects that appear to be hazardous such as walls or rocks but they are constructed with materials and in a manner that is not hazardous to errant vehicles. It is important to minimize the consequences of an errant vehicle that may impact a wall or rocks/boulders. The inner portion of the central island is typically most vulnerable to drivers/vehicles that for some reason leave the roadway and enter the central island at a high impact angle. If in the event that a driver is driving too fast to negotiate a curved approach to a roundabout, or otherwise distracted and/or is not aware of the upcoming roundabout the impact angle entering the central island typically will be much greater than 25 degrees and outside the realm of roadside design. The consequence of hitting a fixed object at an angle greater than 25 degrees is severe.

Minimize the consequence of hitting a wall or boulders by following these guidelines:

1. Do not allow any walls in the central island with cast in-place or reinforced concrete or natural boulders.
2. The wall should be constructed at 20-inch height or lower. This will tend to keep flying debris at a lower level as not to penetrate a windshield, or impact other vehicles.
3. Construct the wall with light-weight Styrofoam/stucco bricks/blocks typically used in landscaping and boulders with chicken wire and stucco. No mortar or reinforcing between the bricks/blocks. Minimize the wall thickness while maintaining stability.
4. Do not allow fill material in back of the brick/block wall for approximately 2 feet. Then at ground level begin to slope the earth up and away from the non hazardous wall at a 6:1 slope of flatter.

Design the slope of the central island with a minimum grade of 4% and a maximum of 6:1 sloping upward toward the center of the circle. The earth surface in the central island area forms an earth mound that is a minimum of 3.5-feet to a maximum of 6-feet in height, measured from the circulating roadway surface at the curb flange. As an absolute minimum, keep the outside 6 feet of the central island free from landscape features

to provide a minimum level of roadside safety, snow storage, and unobstructed sight distance. On the outside 6-feet of central island use some type of pavement surface such as concrete, or stabilized stone like that provided as slope pavement under a bridge. In some situations this central island area may need to maintain a low profile beyond 6-feet to allow OSOW vehicle loads to pass over the central island without the axles passing over the central island, i.e. 165-foot girder.

Avoid items in the central island that may be considered an attractive nuisance that may encourage passersby to go to the central island for pictures, or other objects that might distract drivers from the driving task.

When reasonable, consider a frost proof water supply (small hand hydrant, not fire hydrant) and electrical supply to the central island. The water supply should be considered for long term use not just to establish plant material during the two-year surveillance and care period.

When planning utilities such as water and/or electricity in the central island, they must be discussed with the local unit of government as to need, proximity to the site and who would pay operating costs after installation. Cost agreements shall be included in the project agreement for water and electric costs and agreed to prior to design of the roundabout.

Do not install street furniture in the central island that may attract pedestrian traffic, such as benches, decorative statues, community welcome signs, monuments or large fixed hazardous landscaping objects (walls, rocks, etc.).

Comply with the intersection sight distance as described in the FHWA Roundabout Guide, section 6.3.10.

Landscape design elements for municipalities/communities that are in excess of department standards may wish to seek funding through Community Sensitive Design (CSD) or enhancement funds.

40.2.1 Landscape Design

Landscape design is an important aspect of roundabout operation. Before starting the landscape design first determine the maintaining authority. More flexibility is allowed on projects that are not maintained by WisDOT.

40.2.1.1 Owned, Operated, and Maintained by WisDOT

Low maintenance planting plans for roundabout landscapes are required. Vegetation approved for use by the department requires minimum maintenance and has been demonstrated to tolerate highway site conditions.

The central island earth berm may be planted with trees and shrubs and/or a prairie grass mixture that doesn't require mowing. Plant materials approved for use by the department, including trees and shrubs listed in [FDM 27-25 Attachment 1.3](#) are approved for use on roundabouts owned, operated and maintained by the department. Certain native grasses are also approved at roundabouts and are included in the grasses portion of the "Table of Native Seed Mixtures" in [standard spec 630](#).

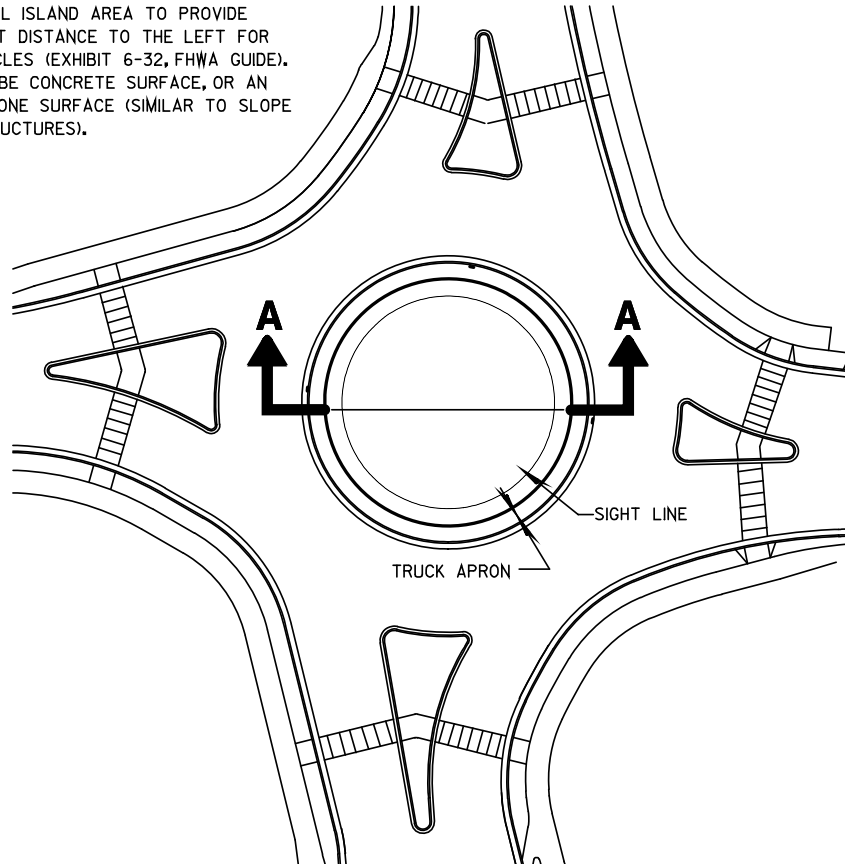
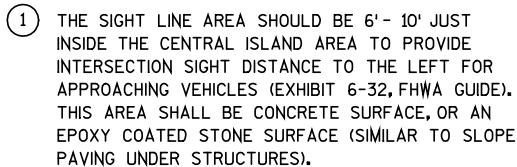
Low-to-the-ground landscape plantings in the splitter islands and approaches can both benefit public safety and enhance the visual quality of the intersection and the community. In general, unless the splitter islands are very long or wide they should not contain trees, planters, or light poles.

Landscape plantings on the approaches to the roundabout can enhance safety by making the intersection more conspicuous and by countering the perception of a high-speed through traffic movement. Avoid landscaping within 50 ft in advance of the yield point. Plantings in the splitter islands (where appropriate) and on the right and left side of the approaches (except within 50 ft of the yield point) can help to create a funneling effect and induce a decrease in speeds approaching the roundabout. Low profile landscaping in the corner radii can help to channelize pedestrians to the crosswalk areas and discourage pedestrian crossings to the central island.

Locations of plant materials shall be selected for salt tolerance and be located to allow for sufficient snow storage in the winter. Snow removal operations typically radiate out from the central island. Plant materials shall not be placed so as to impede snow removal practices.

The uses of pre-emergent herbicides are recommended for use in plant bed and "hardscape" areas. Follow label instructions provided on the product container for use and application procedures.

Contact the Highway Maintenance and Roadside Management Section in the Bureau of Highway Operations for additional landscape design guidance.



DOT but Maintained by Others

40.2.1.3 Local Roads and Connecting Streets

40.2.2 Landscape Maintenance

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40.2.2.1 Owned, Operated, and Maintained by WisDOT

All maintenance costs and operations of roundabout landscaping owned, operated and maintained by the department are the responsibility of the department, except as provided below. Landscape design elements and guidance have been outlined to minimize maintenance and operational costs to the department. Plants shown on the approved list have been selected to best meet these needs, [FDM 27-25 Attachment 1.3](#), [FDM 11-26-30](#) and [Figure 40.1](#) provide detailed layout dimensions of the area to be planted within the central island area.

Only those landscape maintenance operations necessary to maintain the safe operation of the department roundabout will be undertaken.

40.2.2.2 Owned by WisDOT but Maintained by Others

Municipalities often request special landscaping. Landscape requests in excess of requirements contained in Section 2.1.1 are the responsibility of the requesting municipality. Such requests will be considered only upon receipt of a formal, signed municipal agreement approved by the department prior to the design of those roundabouts. This procedure shall be completed early in the planning stages of project development.

40.2.2.3 Local Roads and Connecting Streets

Maintenance and operating costs of roundabouts located on local roads and connecting streets are the responsibility of the local government.

40.3 Multi-use Path Installation and Maintenance.

For urban, suburban, and suburbanizing locations for roundabouts, a circulating multi-use path should be provided. When state and/or federal funds are used they should pay 100 percent of the installation cost of the multi-use path around the outside of the roundabout to accommodate bicyclists that choose to leave the roadway and for pedestrians that may use the crossing. To receive this funding the path shall be constructed at the time of the roadway improvement. When the distance between consecutive roundabouts is around 500 feet or less 100% of the cost of the path between roundabouts should be paid for with State and federal funds also.

Path width guidance is provided in the Wisconsin Bicycle Facility Design Handbook, but generally varies from 6' to 10'. Typically the most common movement on the path is in the same direction as vehicle movement through the intersection, hence they are considered unidirectional. A local agreement is required for maintenance of the path on all three ownership types.

In situations where the local unit of government refuses to sign a maintenance agreement for the path, that refusal must be documented in writing from the local unit of government. The Department should grade the perimeter of the roundabout to accommodate the installation of the path at some future date and cut-throughs should be provided on splitter islands. The cost of the path installation and maintenance after the original roadway improvement is the total responsibility of the local unit of government. There have been situations where land uses change, the local government leaders change, and/or attitudes about such improvements change, or that pedestrian or bicycle volume increase over time, and later there is a strong desire to install the path.

40.4 References

- [1] AASHTO, *An Information Guide for Roadway Lighting*. This is the basic guide for highway lighting. It includes information on warranting conditions and design criteria. AASHTO Bookstore item code GL-5.
- [2] AASHTO, *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. This specification contains the strength requirements of the poles and bracket arms for various wind loads as well as the frangibility requirements. All luminaire supports, poles, and bracket arms must comply with these specifications. AASHTO Bookstore item code LTS-4-M.
- [3] ANSI / IESNA RP-8-00: *American National Standard Practice for Roadway Lighting*. This Recommended Practice, published by the Illuminating Engineering Society of North America provides standards for average maintained illuminance, and small target visibility, as well as uniformity of lighting.
- [4] Centre d'Etudes sur les Reseaux les Transport. L'Urbanisme et les constructions publiques CERTU), L'Eclairage des Carrefours a Sens Giratoire (The Illumination of Roundabout Intersections), Lyon, France: CERTU, 1991.

45.1 Work Zone Traffic Control

During construction, traffic control by police and/or construction personnel (i.e. flagging) may be needed. Space channelizing devices so that the motorist, bicyclist, and pedestrian have a clear indication of the required travel

path and turning radii. This may require closer spacing than the MUTCD would otherwise specify. [SDD15D21](#) and [SDD15D31](#) show example device spacing at turning radii and curve transitions. Evaluate traffic control needs for each roundabout installation on a site-specific basis until the Department develops the expertise in roundabout construction to provide guidance.

45.1.1 Pavement Markings

Because of the confusion of a work area and the change in traffic patterns, pavement markings must clearly show the intended travel path. Misleading pavement markings shall be removed or covered in accordance with the Wisconsin Standard Specifications. As new pavement courses are placed consider specifying in the plans that splitter island delineation and broken white lines on the outside edge of the circulatory roadway be marked the same day the pavement course is placed according to Wisconsin Standard Specifications. When pavement markings are not practical, or misleading markings cannot be adequately deactivated, use closely spaced channelizing devices to define both edges of the travel path.

45.1.2 Signing

Construction signing for a roundabout should conform to the MUTCD and the Standard Detail Drawings. Provide all necessary signing for the efficient movement of traffic through the work area, including pre-construction signing advising the public of the planned construction, and any regulatory and warning signs necessary for the movement of traffic outside of the immediate work area. The permanent roundabout signing may be installed, where practicable, during the first construction stage so that it is available when the roundabout is operable, but these signs must be covered until they are needed. Consider using portable changeable message signs when traffic patterns change.

45.1.3 Lighting

Illuminate the temporary construction area through the intersection where possible. Consider adjacent lighting conditions, traffic volumes during the evening when the roundabout is illuminated, and mixture of use such as pedestrians and trucks.

45.1.4 Construction Staging

The Transportation Management Plan, [FDM 11-50-5](#), will consider detouring traffic away from the intersection during construction of the project. A detour will significantly reduce the construction time and cost and will increase the safety of the construction personnel.

It is desirable to complete construction as soon as possible to minimize the time the public is faced with an unfinished layout or where the traffic priority may not be obvious. If possible, all work, including the installation of splitter islands and striping, should be done before the roundabout is open to traffic.

If it is not possible to detour all approaches, detour as many approaches as possible. Carefully consider construction staging during the design of the roundabout if it must be built under traffic.

Prior to the work that would change the traffic patterns to that of a roundabout, certain peripheral items may be completed including permanent signing (covered), lighting, and some pavement markings that reflect actual conditions. These items, if installed prior to the construction of the central island and splitter islands, would expedite the opening of the roundabout and provide additional safety during construction.

As is the case with any construction project, install appropriate traffic control devices as detailed in the project plans and the Standard Specifications. This traffic control shall remain in place as long as it applies and be removed when it no longer applies to the condition.

Stage the construction as follows unless a different staging plan is approved during design:

- Install and cover proposed signing.
- Construct outside widening if applicable.
- Reconstruct approaches if applicable.
- Construct splitter islands and delineate the central island. Uncover the signs at this point and operate the intersection as a roundabout.
- Finish construction of the central island

If it is necessary to leave a roundabout in an uncompleted state overnight, construct the splitter islands before the central island. Any portion of the roundabout that is not completed must be marked, delineated, and signed in such a way as to clearly outline the intended travel path. Remove or mask pavement markings that do not conform to the intended travel path. Consider adding temporary lighting if the roundabout will be used by traffic in an unfinished state overnight, or install the permanent lighting that is in operational condition.

45.1.5 Public Education

The Transportation Management Plan, FDM 11-50-5, will advise the public whenever there is a change in traffic patterns. Education and driver awareness campaigns are especially important for a roundabout because a roundabout will be new to most motorists. The Regional Communication Manager coordination through both design and construction is typically vital to the success of a project. Provide brochures on how to drive, walk and bicycle through a roundabout. The following are some specific suggestions to help alleviate initial driver confusion.

- Hold public information meetings prior to construction.
- Prepare news releases/handouts detailing what the motorist can expect before, during, and after construction.
- Install portable changeable message signs or fixed message during construction and before construction begins. Advise drivers of anticipated changes in traffic patterns for about one week prior to the implementation of the new pattern.
- Use news media (and Highway Advisory Radio, if available) to broadcast current status of traffic patterns and changes during construction. Also, if appropriate, establish a web site, to post up-to-date traffic and construction information.

FDM 11-26-50 Design Aides

[February 25, 2011](#)

50.1 Plan Preparation Considerations

The overall concept of roundabout plan preparation is similar to other intersection types. The designer should provide the following plan information when designing roundabouts.

50.1.1 Alignment Plans

The designer can place an alignment at many locations throughout the roundabout, and should make the alignment location consistent with other areas of the plan. When locating an alignment near a roundabout the designer should consider the following locations:

- Along the flange line of the splitter islands and central island curb and gutter
- Through the center of the splitter islands and central island.
- Dual alignments along each flange line of the curb and gutter at the splitter island and central island.
- One main alignment as noted above with supplemental layout alignments around the splitter islands and outside curb lines.

50.1.2 Profile Information

The designer can place a profile at many locations through the roundabout. As discussed in [FDM 11-26-30](#), the designer should consider that it is generally desirable from a drive-ability and safety perspective to design and construct the circular component of the roundabout in one plane (planar). Therefore the designer should consider placing a profile around the circulatory roadway or ICD to accomplish the planar design. Once the circulatory roadway profile is established the approach and exit leg profiles can be adjusted or best fit to the circulatory roadway profile. This will usually cause some deviation from the main roadway profile near the roundabout. The designer should try to minimize the distance of the adjusted or best-fit profile from the circulatory roadway to the main roadway.

50.1.3 Typical Sections

At a minimum, roundabout plans should include typical sections at the following:

- Approach and exit to the roundabout
- Within the splitter island
- Within the central island

50.1.4 Plan Details

At a minimum, roundabout plans should include the following plan details:

- Layout details for any alignments utilized for the roundabout
- Layout details for any cross walks and bike ramps if utilized
- Elevation or joint details
- Storm sewer plans
- Landscaping and erosion control plans

- Permanent signing plans
- Lighting plans
- Pavement marking plans

50.1.5 Cross Sections

The plans should include a sufficient number of cross sections through the roundabout to allow for accurate construction of the roundabout.

50.1.6 Example Plan Sheets

Several example plan sheets of the above information have been provided as an aide to the designer when completing roundabout plans. The plan sheets provided are examples and should only be used as guidance. Designers are not required to follow these examples. [FDM 11-26-50.pdf1](#) is a .pdf of the various plan sheets. The PDF attached has bookmarks for the various plan sheets as noted above to assist you in viewing the sheets.

- Example 1: Project Overview
 - Example 2: Typical Section
 - Example 3: Pavement Elevation (Concrete)
 - Example 4: Pavement Elevation (Asphalt)
 - Example 5: Erosion Control
 - Example 6: Storm Sewer
 - Example 7: Landscaping
 - Example 8: Permanent Signing
 - Example 9: Permanent Signing (Interchange)
 - Example 10: Lighting
 - Example 11: Pavement Marking
 - Example 12: Construction Staging
 - Example 13: Construction Details (1 of 2)
 - Example 14: Construction Details (2 of 2)
 - Example 15: Plan and Profile
 - Example 16: Cross Section

50.2 Truck Apron Sizing

The minimum width of a truck apron is 12-feet and may be wider to accommodate OSOW vehicles. Use the WisDOT vehicle inventory of OSOW vehicles to help determine the appropriate truck apron size.

50.3 Creating Roundabout Fastest Paths (Spline Curves)

Spline curves can be created in both Microstation and AutoCAD. In AutoCAD, they are called polylines and in Microstation they are called B-spline curves. The following steps are for creating a B-spline curve in Microstation version 8. Instructions for creating roundabout fastest paths (spline curves) and a guide for using AutoTurn or Auto Track are included in [Attachment 50.1](#).

50.4 RODEL, Stop Delay Verses Total Delay

Please note that most versions of RODEL software (which is used for WisDOT's roundabout evaluations) report roundabout delay as "stop" delay. Stop delay includes only the time when a vehicle is actually stopped while waiting to enter an intersection. This is the way that the Highway Capacity Manual (HCM) reported delay for signalized intersections in the 1985 edition.

Most software that is used today to evaluate intersections controlled by traffic signals reports delays in the form of "control" delay. This is the way the Highway Capacity Manual (HCM) reports delay for signalized intersections in the current 2000 edition.

Control delay is a portion of the total delay including initial deceleration delay, queue move-up time, stopped delay and final acceleration delay. Total delay then includes both control delay and "geometric" delay which is the time that is lost as a vehicle maneuvers through the intersection.

In rare cases where total delay is used/reported for an intersection with a traffic signal or stop control, total delay for a roundabout at the same intersection can be calculated to provide a reasonable estimate by adding the approximate geometric delays found in [Table 50.1](#) to the control delay reported from RODEL (all versions of

RODEL except version 1.9.2 report control delay – version 1.9.2 reports total delay which includes geometric delay, so the geometric delays in Table 1 should not be added to the delay reported from version 1.9.2.).

At roundabouts, the size of the Inscribed Circle Diameter (ICD) has little effect on geometric delay. The approach speed is more important, because the extra distance required to travel around a larger ICD is essentially offset by the faster circulating speed. When comparing traffic operations of a roundabout concept against other intersection types, the main criteria considered should be average seconds of control delay rather than level of service (LOS). LOS can be provided for informational purposes if desired. Control delay should be used when conducting cost/benefit analysis.

Table 50.1 Geometric Delay For Roundabouts

Road Approach Speed (MPH)	Average Geometric Delay per Vehicle (add to RODEL delay to get total delay)
30	9 seconds
40	12 seconds
50	14 seconds
60	16 seconds

When evaluating a roundabout with other intersections nearby, it is extremely important to assess the interaction of the intersections. Chapter 8 of the FHWA Roundabout Guide provides additional information on this topic. This assessment should take into consideration queue lengths, lane utilization, the distance between the intersections,

50.5 Lane Balance

Lane balance and utilization is tested at multilane roundabouts for both peak hours after the geometry has initially been identified. By default, the current version of RODEL assumes equal utilization of all entry lanes at a multilane roundabout. In some situations, incorrect lane assignments (i.e., right, through, left) will affect lane utilization enough to result in significant unbalanced lane use, long delays, and long queues. Therefore, once roundabout geometry is identified at multilane roundabouts, it is important to analyze lane usage by manipulating the “capacity factor” function in RODEL. This will result in identification of proper lane assignments and should be reflected in the concept design. Users need to toggle from the “flow factor” to the “capacity factor” by using the F4 key to test lane balance and identify lane assignments. Once the capacity factor has been enabled, this value should be changed from the default 1.00 to 0.50 (two-lane entry) or 0.33 (three-lane entry) for the leg to be analyzed. This allows the capacity of one lane to be tested with the peak hour traffic volume for a specific turning movement (i.e., right, through, left). The movement to be analyzed must be isolated by zeroing out the other two movements. If the predicted queues and delays for the movement are acceptable using one lane, then the designer can either assign the lane only for that movement (e.g., “left only”, “right only”, etc.) or as a combined use which includes that movement (e.g., “left/through”, etc.). More than one lane may be needed for the movement (e.g., double left, etc.), if queues and delays are not acceptable. This process can be repeated for each movement and each leg to determine lane assignments for the intersection. Based on these results, the designer can adjust geometry and pavement markings.

50.6 Maximum Queue

The “maximum queue” reported by RODEL is the largest total number of vehicles queued on an approach (in all lanes added together) at the end of any one “time slice” during the results period (users should see the RODEL user’s manual for more details on maximum queue, times slices, and results period). The maximum queue is calculated using the 50 percent confidence level. Assuming balanced lane use is achieved, the maximum queue in any one lane would theoretically be equal to the maximum queue divided by the number of lanes. Because the maximum queue is defined as the longest queue at the end of the time slices, it is influenced by the number and length of the time slices which are defined by the user. If the default values are changed to include more/shorter time slices, the maximum queue will usually increase because the default 15-minute time slices can mask some of the variation within each time slice. In situations where queue length is a key issue, detailed queue analysis using times slices of one to five minutes is advisable (queue evolution can be viewed in version 1.9.4 of RODEL using the “F6” key). It should also be noted that the maximum queue is quite different from the 95 percent random queue. The 95 percent random queue is determined by the random variation around the average queue and can be considerably longer than the maximum queue. While it may be longer than the maximum queue, the 95 percent queue only occurs five percent of the time, meaning that it takes place a few days per year, usually for only a few minutes during the peak hour.

The maximum queue is one important piece of information, but the longest queue which is actually observed during a peak hour can be considerably longer than the maximum queue predicted by RODEL. This is due to

random variation and the use of 15-minute time slices as noted above. In order to minimize the potential for queuing problems, designers should assume that the worst actual observed queue during any peak hour could reach up to two times as long as the maximum queue predicted by RODEL. This is especially important when a roundabout is being designed close to an adjacent intersection or where a queue on a freeway off ramp could potentially back onto the freeway mainline. In some unusual circumstances (e.g., special event traffic, holiday weekend traffic, detoured traffic from another route, etc.), the longest observed queue could be longer than two times the maximum queue.

LIST OF ATTACHMENTS

- | | |
|---------------------------------|--|
| Attachment 50.1 | Creating Roundabout Fastest Paths (Spline Curves) |
| Attachment 50.2 | Guide for Using AutoTurn in Microstation Version 8 |